Special consideration is given to what the author terms the soarability of air, the condition that enables it to furnish energy for soaring flight, and the state of the weather as to sun, shade, wind, heat or cold are carefully recorded, as well as the time of day at which birds begin to soar. Soarability is believed to be brought about either by the sun or the wind, and sun soarability is stated to occur at a fairly definite time of day, varying naturally with the season. Here we are reminded of Mouillard's observations on griffon vultures in Algeria and his similar statement that they do not begin to sail until the sun is well above the horizon. The author seems inclined to have at first considered that there was a direct connection between heat eddies, indicating rising currents of air, and soarability, but later decided that this was not the case. And yet the curve showing time of appearance of heat eddies for a month coincides absolutely with the time of sun soarability.

Readers may recall, though Dr. Hankin does not mention it, the theory that soaring is effected by ascending currents of air impinging on the curved, though very minute, barbules of feathers. Wind soarability is believed to be due to some inherent property of the air and not to mere velocity, and throughout the book one notes the author's evident feeling that birds, flying fishes and dragon flies obtain energy from the air in some occult, or at least unknown way. Occult it does seem, to any one who has watched an albatross gliding into the eye of the wind or tacking back and forth, perfectly at ease in a driving gale. Wonderful it certainly is in view of the infinitesimal expenditure of muscular energy, but, remembering Langley's memoirs on the internal work of the wind and the strong and varied eddies that he showed might be present in an apparently steady breeze, one feels that birds with their thousands of years of experience and automatic adjustment to every air current can derive sailing energy from, to us, invisible sources.

Great attention is paid to the use of the wings and tail, and careful records are given of their varied motions, positions and relative angles to the body in directing, accelerating or checking flight; all of which are most valuable.

An extremely interesting chapter is devoted to the Flight of Flying Fishes, containing carefully-made and well-recorded observations of the character of their flight and the conditions under which it is made. The conclusion reached is the same as that of Colonel Durnford, that they do actually fly, and that initial impulse is utterly inadequate to account for the long distances covered, the sustained speed and ability to change direction when on the wing.

We are introduced to a considerable number of new words, or new meanings, such as soarability, flex-gliding, tail-jolting, and while at first sight these seemed unnecessary, yet on further perusal one was forced to admit that they conduced to brevity and clarity of statement. Lexicographers will find these new words and terms carefully defined in a glossary and will duly thank Dr. Hankin for his thoughtfulness and commend it to future coiners of words.

F. A. L.

## *RECENT STUDIES IN ANIMAL PIGMENTATION*

MUCH has been written on animal pigmentation from both the biological and the chemical standpoint, but the views regarding the nature and origin of pigment are still at variance. Perhaps the chemists have made most progress in determining the chemical nature and composition of animal pigment, especially of that form known under the name of melanin, which occurs either normally or pathologically in the animal body, hair or feathers. Dr. Ross A. Gortner, of the Cold Spring Harbor Station for Experimental Evolution, who has devoted a number of years to this subject, states that the black humic substances, known as artificial melanin or "melanotic substances," resulting from the hydrolysis of proteins by strong mineral acids, or the dark products formed by the action of oxydases upon aromatic or heterocylic phenols may sometimes be shown to be related to the melanins, but until that relationship is demonstrated, they should not be confused with the true animal pigment. He accepts the theory suggested by von Fürth, that all pigments are formed by the action of an oxidase of the tyrosinase group on an oxidizable chromogen, and demonstrates his claim by experiments with meal worm and the cicada.[1] In the former he finds that the normal coloration develops after the death of the larva, *i. e.*, after the secretion of the enzyme has ceased, while in the latter life is necessary to produce the normal coloration, although the enzyme once formed does not depend upon life processes. Accordingly, the rise of the true melanins is closely bound up with the enzymes and demands a biological investigation as well as a chemical, if such distinction is still justifiable in the light of modern chemico-physical interpretations of life phenomena.

During twenty years of experimentation I have found the oyster (*Ostræa Virginiana*) the most convenient and fruitful animal for the investigation of the nature and origin of pigments, because it can be easily handled and the conditions of light, temperature, food supply and pathological changes are readily controlled. My earlier experiments which were published from time to time in the *Proceedings of the Academy of Natural Sciences* of Philadelphia, 1893, in the *Bulletin of the University of Pennsylvania*, in the *Annals and Magazine of Natural History of London* and in the *American Journal of Physiology*, exclusively dealt with the influence of light on animal tissue under pathological conditions. My latest experiments, permitted through the courtesy of Dr. C. B. Davenport at the Cold Spring Harbor Experiment Station, took into consideration light, temperature, food supply and the absence of pathological influences. Several hundred oysters were opened without injury to the adductor muscle or any other part of the animal, except the shell, and placed on wire netting in a trough through which sea water flowed with varying degrees of velocity. Some of the oysters were placed within the fraction of an inch of the water surface, others at varying depths down to six inches or more from the surface. Enough of the left shell was removed to expose the greater part of the left mantle, the pericardium, the gills and the inner edge of the right mantle. The experiments were carried on from July 6 till August 15 at a time when the sun's rays are most effective and in a place exposed to the full sunlight during at least eight hours of the day. Eighty per cent. of all the oysters died after a few days of exposure; the remainder gradually darkened all over the exposed surface turning first light brown and finally jet black, while the removed shell was slowly regenerating along the broken margin. The temperature of the water varied on different days between 50 and 70 degrees Fahrenheit, with slight variations of several degrees between the various depths. There was also a difference in the quantity of the excreta, being enormously large in the oysters placed nearest the surface, showing a difference in the quantity of the food and in the oxydation process. The latter also blackened most rapidly, particularly along the gill bars and over the tentacles of the mantle. All the indications showed that the surviving oysters would fully regenerate their shells and continue to live as though nothing abnormal had occurred. In his experiments with the cicada Dr. Gortner found that the insect just emerged from the pupal shell and exposed to the action of the air rapidly turned black without regard to light, for several colorless adults which he exposed to strong light, dim light, total darkness and light which had passed through blue glass, showed no apparent difference in the rapidity of coloration nor in the final depth of color. Nor did Victor Faussek observe even a trace of additional pigmentation when he exposed oysters for many weeks to the direct rays of the sun or a diminution of the normal pigment when he placed them for several weeks in darkness. In all my experiments the phenomena of pigmentation and depigmenta-

[1] "Studies on Melanin," I., Method of Isolation, *Journal of Biol. Chem.*, 1910, II., The Pigmentation of the Periodical Cicada, *Journal of Biol. Chem.*, 1911, III., "The Inhibitory Action of Certain Phenolic Substances upon Tyrosinase," *Journal of Biol. Chem.*, 1911.

tion under the influence of light were very marked and never failed as long as the animals remained alive, while dead tissue generally disintegrates without change in pigmentation, due to bacterial fermentation. Gortner has proved that, in the case of the cicada, the oxidase is secreted together with the new cuticula, which ceases to be formed in the absence of life processes, for, when he washed and rubbed dead adults in a stream of water coloration took place only in spots, mostly in the folds of the abdomen, where the cuticula had not been completely removed, while other adults which had been as thoroughly washed but not killed, slowly darkened to the normal color. We may have a similar condition existing in the living oyster in which the regeneration of the shell, the homologue of the cuticula, takes place. In the case of the oyster, however, light must play the chief rôle, for when placed in darkness the depigmentation takes place in the epidermis of the oyster while the shell continues to grow, and, besides, pigmentation always takes place over the gills, the epidermal cells of which do not form a shell. Faussek's negative results with light can only be explained on the basis of the additional factor of temperature and perhaps of food conditions. If the oysters were placed so far below the surface of the water that the refraction caused a decomposition of the light and a consequent lowering of temperature or maximum energy and with it a diminution in the food supply the conditions for pigmentation became unfavorable and the results negative. On the other hand, Gortner's observations on the noninterference of light with process of pigmentation can be explained on the basis of the normal occurrence of maximum pigmentation in the cicada under any light condition as a hereditary factor, while in the oyster the epidermis of the mantle with the exception of the mantle edge is colorless when covered by the shell: the mantle edge is pigmented because it is generally free from the shell and exposed to light. In the one case contact with the atmosphere through the cuticula is essential, in the other light and temperature, for we find that oysters at certain depth or when covered with mud are lacking the pigment even in the mantle edge.

So much for the purely physico-chemical sources of pigmentation. Considering the biological side of pigmentation, a study of the structure of pigments and pigment cells is essential. There are different views on this subject. It is, however, generally agreed that pigments occur both as excretions and secretions either in a diffused or in a segregated form; in the one case they may be masses of colored granules represented by bilirubin, urochrome, melanin, etc., in the other they may be variously shaped cells, called chromatophores or melanoblasts. Keller distinguishes in the chamæleon melanophores, leucophores, ochropores, xanthophores and erythrophores, while Kromayer argues that pigment cells are not cells, but epithelial figures which, however, can not be isolated. Reinke again distinguishes between pigment carriers and pigment substance, the latter consisting of colorless prisms, scales, granules, etc. Ehrmann holds that "melanin is intra-cellular, and in the situations where it is present it occurs in the deeper layers of epidermal cells and in certain mesoblastic cells known as melanoblasts. The melanoblasts are specialized connective tissue cells which are round, spindle-shaped, or branching, and are peculiar not only for containing melanin granules, but also for having larger nuclei which stain more faintly than those of ordinary cells. Melanoblasts occur in the upper layers of the corium, are especially noticeable around the blood vessels and are also present as peculiar structures in the interepithelial lymph-spaces of deeper portions of the epidermis. The substance is a derivative of blood pigment, the material of which it is formed getting out of the blood vessels into the perivascular tissue spaces, where it is taken up by the melanoblasts and transformed into melanin. The epidermal cells do not elaborate melanin, but absorb it from the melanoblasts in the interepithelial lymphatics." The most recent views on the nature and origin of pigment in the sebaceous glands of certain Cavicornians have been advanced by Weber, Beccari and

Brinkmann.[2] Weber maintains that the black pigment granules of those organs are partly distributed like fine dust particles in the cells, partly united in small lumps, and the pigment is mixed with the secretion. He observed chromatophores which entwine the grandular acini, but emphasizes that the pigment is not derived from these acini, but from the sebaceous cells themselves. Beccari and Brinkmann, on the other hand, have more recently and independently of each other made the observation that the pigment is not formed in the glands themselves, but in the chromatophores mentioned by Weber and transported as finished products into the glands. Brinkmann describes the process as follows:

> The chromatophores, or more correctly the melanoblasts, as I call them, originate in the connective tissue, they are strongly anastomosing structures which, laden with melanin, migrate as far as the alveoli of the sebaceous glands. They are not only entwined by them, as Weber thinks, but the melanoblasts penetrate the connective tissue capsule of the gland and push themselves in between the cells of the gland. According to Beccari's investigations the amœboid process of the melanoblasts penetrate into the cells and deposit their pigment: this last phenomenon I could not confirm by direct observation, only the fact that they migrate into the cells.

Another noteworthy view that may be cited from the vast literature on the subject is that of Jarisch, who holds that there is a definite relation between the nuclear chromatin and pigment; certain chromatin particles, the tingible or pyrogenous bodies, are formed and changed into pigment balls. Luckjanow and Steinhaus have actually observed pigment masses arising around the nucleus in sarcoma and Maurer and Fraisse confirm this observation for the epithelial nucleus of *Pleurodeles* when it is the result of the degeneration of the nucleus being accompanied by the shrinking of the nucleus. This reminds us very vividly of Richard Hertwig's doctrine of the chromidial apparatus which involves the migration of chromatin particles from the nucleus into the cytoplasm. Goldschmidt very ingeniously enlarged this doctrine into the doctrine of the duality of the nucleus, according to which every animal cell is doubly nucleated, containing a somatic and a reproductive or genetic nucleus, the former performing the functions of metabolism and motion, the latter that of reproduction and transmission, the somatic nucleus representing Hertwig's chromidial apparatus. I mention all these recent views on the possible origin and nature of pigment formations, because they throw some light on my own observations. The histological knowledge of the mantle tissues of the oyster is still very inadequate, notwithstanding the classic investigations of Rawitz on "Der Mantelrand der Acephalen." We know in a general way that the epidermis consists largely of cylindrical cells, many of which are goblet cells filled with mucus; others are ciliated pigmented and nonpigmented cells, especially along the mantle edge. There are also numerous small mucous glands active in the formation and growth of the shell; a rich nerve plexus enervates the mantle edge and a large blood vessel with numerous blood lacunæ supplies the necessary food while a series of muscle bundles controls the contraction and expansion of the mantle. I made careful histological sections of the mantle of oysters not exposed to the direct rays of the sun, as well as of those that had been exposed various lengths of time. I also macerated blackened mantle tissue in the fresh state. In the unexposed specimens the pigment was confined to cylindrical cells along the mantle edge. The pigment granules were evenly distributed throughout the cytoplasm in most cases; in some there was a denser massing of granules along the outer margin of the cells, otherwise the mantle was free from pigment. Sections of the exposed mantle showed the presence of pigment granules in all the cells of the epidermis not only in the mantle but also in the gills and in the connective tissue cells of the pericardium. Macerated mantle

[2] N. Beccari, "Richerche intorno alle tasche ed ai corpi ghiandolari suborbitali in varie specie di Ruminanti," *Arch. ital. di Anatom e di Embriol.*, Vol. 9, 1910. A. Brinkmann, "Bidrag til Kimishaben om Drövtyggernes Hudkirtelorganer Vidensk. Medd. fra nath. Foren," København, 1911.

portions of specimens exposed more than four weeks to the direct rays of the sunlight proved most satisfactory. They exhibited all the stages of pigment formation suggested by the various theories, epidermal cells in which the pigment was densest around the nucleus with the nucleus in a shrinking condition, confirming the theory of Jarisch and others; further intercellular pigment masses with amœboid processes situated between mucous cells and glands similar to the melanoblasts observed by Becarri and Brinkmann. Also pigmented masses along the blood vessels of the gills undoubtedly stimulated by the respiratory changes in the circulation of the blood, but the largest pigment mass consisted of innumerable spherical bodies of accumulated melanin granules which covered the epidermis of the mantle and were held by a layer of mucus exuded from the cells and forming the ultimate fate of the pigmentation process. In specimens that had been returned to the dark after several weeks most of the pigment had disappeared, and where present was confined to the original pigment cells of the epidermis, largely along the mantle edge, with scattered disintegration products of pigment granules throughout the epidermis.

Though the work is still tentative, I have come to the conclusion that animal pigmentation is probably a protein formation due to an enzyme which is circulating in the blood and present in the nucleoplasm of all secreting cells. This, of course, could only be proved by chemical analysis. In some cases the leucocytes are transformed into specific chromatophores or melanoblasts, capable of amœboid motion; in others the deposition of pigment has become a hereditary factor, as, *e. g.*, in the choroid coat of the eye or the ink-bag of the squid; in still other cases pigmentation is stimulated into action by internal metabolic processes as well as by external conditions of light, temperature and atmospheric gases. In the case of the oyster light is the chief factor in the stimulation of pigment, which is the result of protective reaction against abnormal conditions. But this reaction is in my judgment not merely chemical, it is preeminently biological and under the control of nuclear determinants.

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## *SPECIAL ARTICLES*

### SUPPRESSION AND LOSS OF CHARACTERS IN SUNFLOWERS

*Helianthus* and *Œnothera* are very little related, yet in breeding and studying sunflowers one is constantly reminded of phenomena previously recorded in connection with evening primroses. The parallelism in variation is such that one is led to ask, what, precisely, do we mean by a "new" variation? A "new variety" can be easily defined as a distinguishable type arising in a species, and either "new" in the sense of being newly discovered, or (as we believe to have been true of the red sunflower) actually originating within the period of our knowledge. We have thought it highly satisfactory to be able to list[1] instances of newly occurring varieties or mutations, with some suggestions regarding their proximate causes, but it must not be forgotten that in so doing we have gone only a little way below the surface. If many plants, of widely different families, produce entirely analogous variations, it must be true that there is something in the constitution of the whole series which makes the apparent accidents inevitable. One is reminded of the occasion when Whistler made an exceptionally good joke, and Oscar Wilde, who was present, remarked, "I wish I had made that joke!" Whistler replied, "My dear fellow, don't worry, *you will make it.*" So might the *Gaillardia* have said to the sunflower, five years ago, though without the sarcastic intent.

The commonest of all variations results from the loss of a character, but this may be due to latency, or to the dropping out of a determiner. In sunflowers, the "primrose" varieties, with pale primrose-colored rays, offer a typical case; another, of which a single example occurred in

[1] Gates, *Quart. Jour. Micr. Science*, Feb., 1914, pp. 562–563, gives an excellent tabulation of the principal types of mutation.