Cellular Aspects of the Control of Color Changes

AAAS Symposium • 29 December 1968 • Dallas, Texas

Color changes in animals have been known since the time of the ancients and have continued to interest both scientist and layman. The rapid color changes of the octopus and the remarkable pattern-imitating ability of the flounder and African chameleon are familiar to all. A great deal is presently known about the organismal aspects of the control of color changes. However, in order to discuss the control of the pigment cells (chromatophores) responsible for these changes, a symposium will be held 29 December 1968 during the AAAS Annual Meeting in Dallas, Texas. This symposium, Cellular Aspects of the Control of Color Changes, has been organized for the Division of Comparative Endocrinology of the American Society of Zoologists. Proceedings will be published in *American Zoologist*.

Chromatophores are of two types, that found in the octopus and other cephalopod mollusks, and the type found in other cold-blooded animals. The cephalopod type consists of a pigment-containing cell surrounded by radially arranged muscle fibers, which are innervated. This type, which is actually a tiny organ, has been the subject of recent extensive physiological and ultrastructural studies, to be presented in the first paper of the symposium. The other chromatophore type will be thoroughly discussed in the next six papers. It usually consists of a cell with numerous processes, within which the pigment disperses or aggregates in response to specific stimuli. Chromatophores of this type are under hormonal control in some animals (crustaceans, some fishes, amphibians, and some reptiles) or under nervous control in others (teleost fishes and some reptiles). In some species, for example, certain teleost fishes, both nervous and hormonal control mechanisms exist, but usually one of these predominates. In addition, the control of color in birds and mammals will be the subject of the last two papers, even though these animals lack true chromatophores. However, they do have melanocytes, whose primary function appears to be the donation of melanin pigment to overlying epidermal elements, for example, Malpighian cells, feathers, or hair. Their control by hormones, gene action, and external radiations offer many interesting examples of pigmentation control of special relevance to man.

There are a number of still unanswered questions regarding chromatophore physiology in crustaceans and cold-blooded vertebrates. For example, the exact mechanisms by which the pigment granules disperse or aggregate are still unknown. However, recent electrophysiological studies have provided useful information bearing on this fundamental question. Furthermore, the demonstration of the existence of microtubules by electron microscopy in the melanophores of a species of teleost fish has shown that these structures may be involved in the movement of melanin granules (melanosomes). A related question concerns the mechanisms by which hormones or neurotransmitters produce pigment granule movements within chromatophores. For example, pituitary melanocyte-stimulating hormones (MSH's) produce melanosome dispersion in frog melanophores, but pineal melatonin or epinephrine produce melanosome aggregation. The mechanisms by which effects such as these are produced are still unknown, but studies on the osmotic and ionic requirements for these effects have provided information supporting certain possible mechanisms. Tissue-cultured melanophores have also been useful objects for studies of this type. More recently, information has been accumulating that the melanin-dispersing effect of MSH may be produced by an increase in the intracellular levels of adenosine 3′,5′-monophosphate (cyclic-AMP) in the melanophore. Since the actions of epinephrine on other cells are known to involve cyclic-AMP, it may eventually be possible to explain the effects of MSH, norepinephrine, and epinephrine in terms of cyclic-AMP. In addition, the availability of pure vertebrate chromatophore hormones and the increasing state of purification of crustacean hormones permit the kind of experiments necessary to answer questions such as these.

There are also numerous interesting unsolved problems regarding morphological color changes, wherein there is an actual increase or decrease in the amount of pigment or number of chromatophores as a result of long-term adaptations to background. Recently, extensive studies of the comparative enzymology of vertebrate tyrosinase, the enzyme catalyzing melanin synthesis, have provided important information in this area of study. Although the changes of color occurring in birds and mammals are technically not regarded as morphological color changes, they do involve changes in the actual amount of pigment in the skin. Recent studies of the action of hormones, for example, the luteinizing hormone (LH), on weaver birds and of radiant energy on mammalian melanocytes afford additional examples of the effect of various agents on pigment formation.

Finally, the symposium should be of broad interest to endocrinologists, neurobiologists, and pharmacologists, since some of the hormones, neurotransmitters, and drugs which affect chromatophores also have effects on a variety of other cells, for example, neurons. It may also have wide appeal by showing that pigmentation is only one of a broad spectrum of characteristics by which an organism adapts to its environment.

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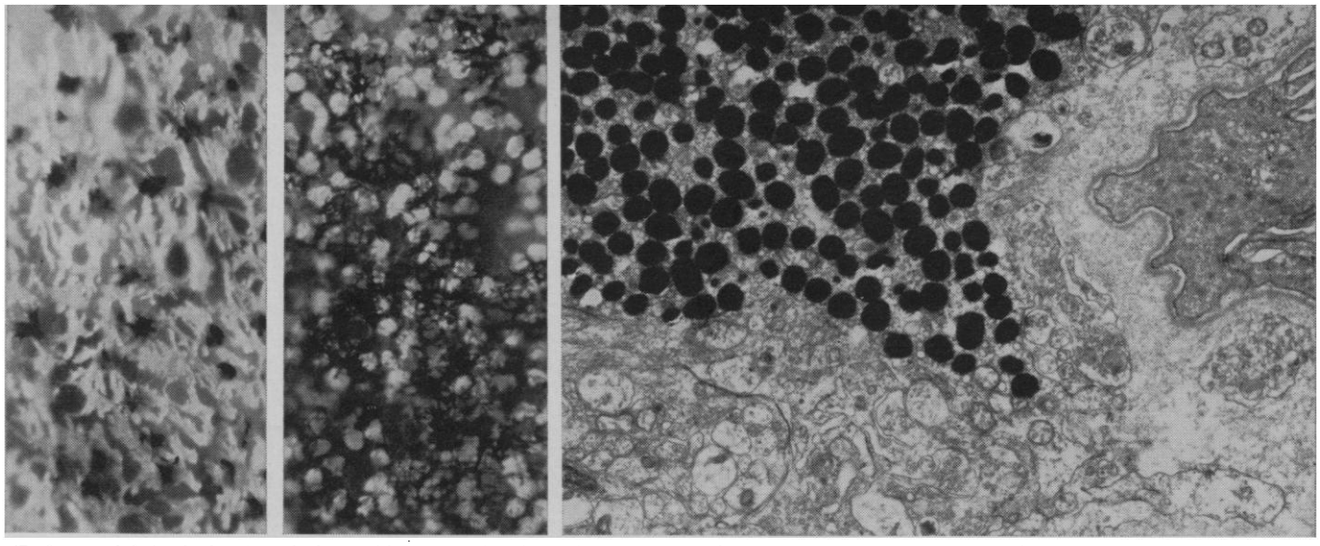
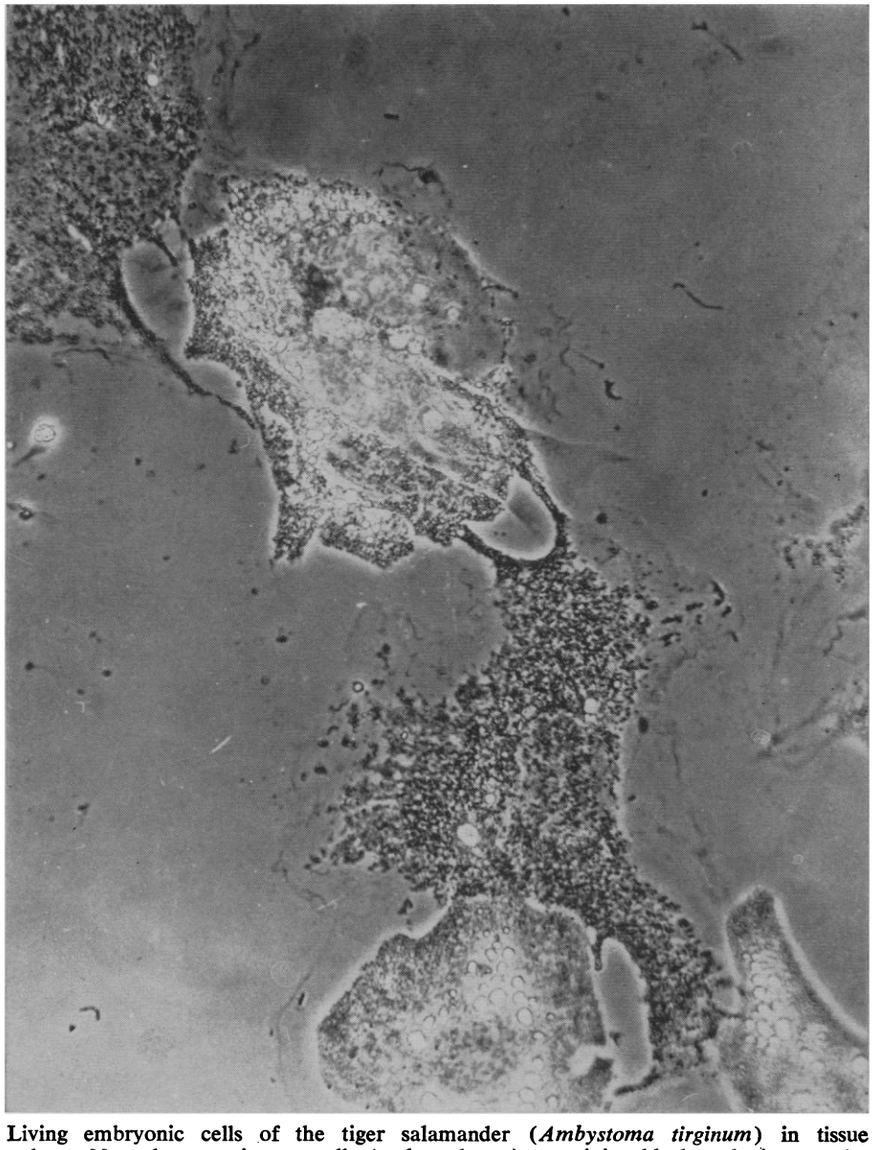
Program details and illustrations appear on the following page.



(Left to right). Pale dorsal frog skin; note black melanophores with aggregated melanin pigment and white iridophores (guanophores) with dispersed reflecting pigment. Dorsal frog skin darkened by MSH; note melanophores with dispersed melanin and iridophores with aggregated pigment (× 140). Part of a teleost fish (guppy) melanophore with aggregated melanin granules (melanosomes); note nervous elements surrounding the melanophore (× 9800). [R. Fujii]



Living embryonic cells of the tiger salamander (*Ambystoma tirginum*) in tissue culture. Note the two pigment cells (melanophores) containing black melanin granules (melanosomes) (about × 520). [Ronald R. Novales, Northwestern University]

Speakers and Topics

Arranged by Ronald R. Novales (Northwestern University)

29 December (morning)

Chairman: Ronald R. Novales.

Ultrastructure and Physiology of Cephalopod Chromatophores, E. Florey (University of Washington).

Physiological Color Changes in Crustaceans, M. Fingerman (Tulane University).

Physiological Color Changes in Fishes, R. Fujii (Northwestern University).

The Control of Bright-Colored Pigment Cells of Fishes and Amphibians, J. T. Bagnara (University of Arizona).

General Discussion.

29 December (afternoon)

Chairman: I. I. Geschwind (University of California, Davis).

Physiological Color Changes in Amphibians, R. R. Novales.

Physiological Color Changes in Reptiles, M. E. Hadley (University of Arizona).

Morphological Color Changes in Vertebrates, W. Chavin (Wayne State University).

The Control of Color in Birds, C. L. Ralph (University of Pittsburgh).

The Control of Color in Mammals, W. C. Quevedo, Jr. (Brown University).

Review of Science Policy in the United States

AAAS Invited Lectures
Arranged by Eugene B. Skolnikoff
(Massachusetts Institute of Technology)

29 December (morning)

Part I

Chairman, Herbert Hollomon (University of Oklahoma, Norman).

Dicussants: Conrad Waddington (Edinburgh University, Edinburgh, Scotland), O. M. Solandt (Chairman, Science Council of Canada), and Alexander King (O.E.C.D., Paris, France).

29 December (afternoon)

Part II

Chairman, Don K. Price (Harvard University).

Speaker, Donald Hornig (Special Assistant to the President for Science and Technology). Panel discussion with questions from the floor (Donald Hornig, Conrad Waddington, Alexander King, Herbert Hollomon).

The two-part symposium will be concerned with an evaluation of U.S. science policy and science policy machinery and with a discussion of the issues that should be brought into focus in the next administration.

The first two speakers were members of the Organisation for Economic Co-operation and Development team of examiners that reviewed science policy in 1967 and early 1968. They will present their general findings and any modifications of further thoughts that arose in the year since preparing their report. King will present a more general evaluation based on his many years of involvement in issues of science policy of concern to most Western nations.

The second session will have Donald Hornig as the primary speaker who will present his own views of current and future issues in the U.S. science policy-making. Following Hornig's talk, there will be opportunities for questions from the floor that may be addressed to any of the panelists from the morning or afternoon session.

Panel: Science, Technology, and Latin American Development

Arranged by Harrison Brown (California Institute of Technology)

30 December (afternoon)

Chairman: Harrison Brown.

Prospects for Food Production, H. F. Robinson (University System of Georgia).

Demographic Problems, Harley Browning (University of Texas, Austin).

The Social-Political Problems of Development, Richard N. Adams (University of Texas, Austin).

A round-table discussion will follow.

31 December (morning)

Chairman: Harrison Brown.

Bilateral and Regional Scientific-Technological Development, Theresa Téllez (National Academy of Sciences).

International Transmission of Technology by Means of Private Investment, Dwight Brothers (Harvard University).

Science Policy and National Economic Development in Latin America, Victor Urquidi (Colegio de México, Guanajuato, México).

This symposium will focus on the interdisciplinary approach to problems of economic development in Latin American countries, particularly through the avenues which science and technology offer. With increasing attention being given to the importance of an adequate scientific-technological base for economic and social development and with the technological gap widening between Latin America and the more advanced countries, it is especially appropriate to discuss as many facets of the problem of development as possible.

The discussants will address themselves to immediate questions, such as food production and population growth, but will also raise fundamental issues such as: What is the role of science and technology in economic development? How much basic and fundamental research should be invested by national governments and by private industry? What are the educational requirements for a scientific base? What are the social and political implications? What types of bilateral and regional scientific programs are possible?

The participants have all had personal involvement with such questions in Latin America and will lend a diversity of views and expertise to what is intended to be a comprehensive picture of the present situation in the region.