Preface

A necessary limitation of any compilation on eye development is precisely its strength: the field is so broad and intensively studied that it is not possible to do it justice in one issue. Eyes are widely distributed and diverse. Simple organelle eyespots exist in protozoa and unicellular alga, and highly simplified eyes are present in larvae of sponges and jellyfish. Adult cubomedusan jellyfish have sophisticated eyes (ocelli) with ciliated photoreceptors (like vertebrates) and cellular lenses as well as lens-less ocelli; ancient flatworms, marine annelid worms and the protochordate ascidian larva have complex eyes with a rudimentary lens, photoreceptors and pigment cells. Insects have both lens-containing ocelli like the jellyfish and compound eyes that comprise hundreds of separate facets, the ommatidia, each with their own few rhabdomeric photoreceptors. Some shrimps have compound eyes to detect polarizing signals from each other, while other crustacea use specialized eyes to capture stray photons created by thermal vents in the depths of the ocean. Scallops use rows of mirrored, camera-type eyes with lenses along the mantle that cast focussed images on double retinas using separate phototransducing pathways to feed or evade prey. Salmon have specialized cones in their retina that appear transiently in geometric patterns to orient polarized light for the fresh water stint of their extensive migrations. The eyes of the 'four-eyed' surface fish, *Anableps*, are divided into a dorsal half used in air above the water surface and a ventral half submerged in water; each half uses the same lens but has a separate cornea and retina. Mice see shades of grey and ultraviolet; eagles and butterflies see brilliant color. The human eye serves us well, but we lack the resolution of the eagle, or the night vision of the owl, or the ultraviolet vision of the mouse and insects. These are but a sprinkling of eyes populating our planet. This Special Issue of *The International Journal of Developmental Biology* touches on the development of some of these remarkable eyes, regrettably few, but we hope it kindles your interest to learn more.

In view of the evolutionary approach (Evo-Devo) to understanding development, this Special Issue discusses ideas concerning the origin of numerous eye types. Interpretations for the repeated use of similar developmental cascades in diverse eyes are weighed with respect both to the elaboration of different eyes from a single primordial source as well as to the recruitment of suites of genes for the evolution of new eyes. The present issue considers the common use of rhodopsin for phototransduction and the species-specific use of multifunctional lens crystallins for refraction. The concept of homology of organs becomes blurred as our knowledge of molecular evolution grows exponentially at a dizzying speed raising questions of how to quantify partial homology. Even the possibilities that primordial eyes preceded brains or were transferred to metazoans via horizontal evolution are considered here.

The vertebrate eye and its development have fascinated researchers for ages, and eye formation has served as a model for development ever since the famous lens induction experiments of Warren Lewis and Hans Spemann a hundred years ago. Thus, this issue considers historical aspects of eye development as well as modern revisions and current molecular data. In recognition that science is advanced by devoted investigators, we present interviews with two important contributors to eye development, Dr. Elizabeth D. Hay from the United States and Dr. Goro Eguchi from Japan.

The present issue on eye development covers a vast array of topics in different species and eye tissues. Articles devoted to eye development, retinal specification and photoreceptor differentiation emphasize the striking similarities between eye development in flies and mammals. Other topics include the organization of cone mosaicism in the zebrafish retina and guidance decisions made by axons when wiring the eye to the mammalian brain. The actions of neurotrophins for morphological development of retinal ganglion cells and for visual connectivity and synapse formation are reviewed. The roles of apoptosis for sculpting the developing retina in different species and for eye regression in the blind cavefish are elucidated. Molecular mechanisms of cell movements, cell:matrix interactions and cell adhesions in lens development are additional aspects of eye development presented in this volume.

The eye is more than an organ; it is a compilation of organs. One article describes the extraordinary, geometric architectural achievements of lens development, while another article summarizes the complex differentiation of the cornea involving the extracellular stroma, the external epithelium and internal endothelium, and the associated tear film. Inductive and tissue specification processes critical to eye formation start in development well before the appearance of an eye, and experiments concerning the timing and nature of these early developmental events are presented. The pivotal roles of conserved transcription factors (Rx and Pax6 among many others) for eye development are featured in these articles, as are molecular details of tissue-specific gene expression, especially the lens crystallin genes. The varied and important roles of diverse growth factors and signaling systems governing eye development are covered in several articles. The eye contains some of the most differentiated cells of the body (anucleate lens cell fibers, photoreceptors) as well as stem cells. Articles covering the biology of limbal corneal, conjunctival and neural retinal stem cells included here are of developmental and clinical interest. Lens regeneration from the iris in the newt and retinal regeneration in various species from different cellular sources represent other examples of cellular plasticity in the eye. Clinical aspects of eye development are also considered in articles on the anterior segment and glaucoma, the development of the hyaloid, choroidal and retinal vasculature, and hereditary cataract.

Finally, we express our thanks to Prof. Juan Aréchaga and his editorial team for having provided us with the opportunity to compile and edit this unique collection or papers in a Special Issue of *The International Journal of Developmental Biology*. We have learned much in having had the privilege of putting together this Eye Development issue and we hope that you too benefit from the wealth of information presented here. Enjoy it!

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