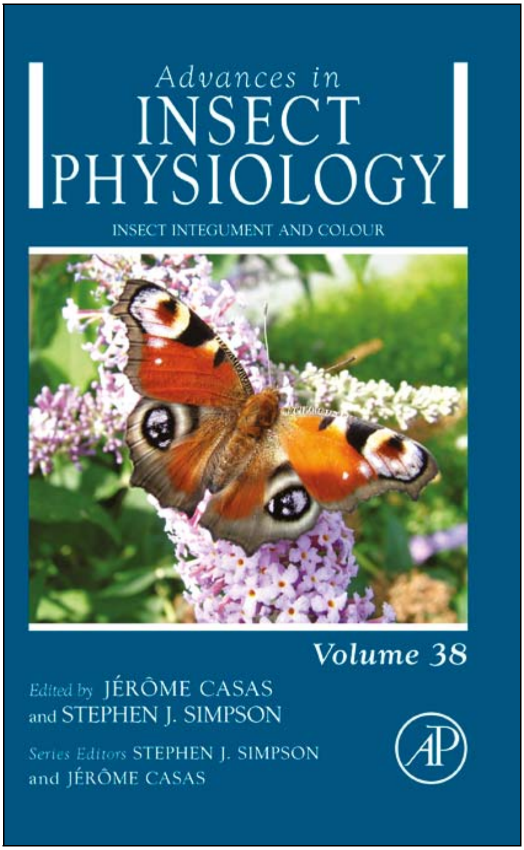

From: Jérôme Casas and Stephen J. Simpson, Increasing Demands and Vanishing Expertise in Insect Integrative Biology. In Jérôme Casas and Stephen J. Simpson, editors: *Advances in Insect Physiology*, Vol. 38, Burlington: Academic Press, 2010, pp. 1-4.
ISBN: 978-0-12-381389-3 © Copyright 2010 Elsevier Ltd.
Academic Press.

Increasing Demands and Vanishing Expertise in Insect Integrative Biology

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We regard *Advances in Insect Physiology* as the journal in which deep, lasting reviews and syntheses can be published, at a level of comprehensiveness which precludes publication in other venues. The planning and production of each volume is therefore an exciting moment for the editors. It is the time when we hope to identify those fields which are setting tomorrow's agenda, and to discover those areas which are losing ground, often silently. We were unexpectedly surprised by several conflicting trends while producing this volume; trends which apply more broadly than to insect integument and colour, but rather are relevant to the entire field of insect integrative biology.

Insects can be astonishingly colourful and often display extremely delicate patterning. This variety is endless, and there is sustained interest in explaining these patterns, in particular iridescence, as exemplified in two recent books (Berthier, 2009; Kinoshita, 2008). Even the interdisciplinary *Journal of the Royal Society Interface*, which puts equal emphasis on physics, chemistry, mathematics and biology, had a thematic issue on iridescence, in which insects have a prominent place as study objects (Meadows *et al*., 2009), sandwiched between a thematic issue on quantitative fluorescence microscopy and one on Biomaterials Research in Japan. Why such a widespread interest? The potential applications in art, design and industry are worth billions per year, as in more fundamental optics (Vigneron and Simonis, this volume). For example, the paint industry is interested in iridescence. Because it contains fragments of multilayer slabs that orient themselves due to surface tension effects, some paints can change colour with the angle of viewing, as measured from the surface normal. The same effects can be achieved, for instance, in cosmetics. As Vigneron and Simmonis explain (this volume), in nature there are examples of total reflection, thin-film filtering, gratings, photonic crystals, lenses, parabolic mirrors, optical fibres, solid-state light sources and much more.

ADVANCES IN INSECT PHYSIOLOGY VOL. 38
ISBN 978-0-12-381389-3
DOI: 10.1016/S0065-2806(10)38012-X

Natural selection has put two gratings on the same surface, and yielded other effects that we have not yet invented. Chitin, one of the building blocks of these structures, is also used worldwide for numerous purposes. Due to their biodegradability, biocompatibility and non-toxicity, chitin, chitosan and their chemical modification products cover a large range of useful applications. The textile and pharmaceutical industries as well as agriculture, water treatment, cosmetics, food and photography use them (Cohen, this volume) and one can only wonder how this complex material is produced and works. It also represents a high point in the evolution of load-bearing tissues due to the rate of maturation, low density, tunability and robustness of its mechanical properties, as well as its resistance to moisture, among other properties (Rubin *et al*., this volume).

Biomimetics, which we have already referred to in an earlier volume (Casas and Simpson, 2008), is becoming an increasing force in the development of new technologies; insects, by their sheer variety, are an endless source of inspiration. Behavioural ecologists, too, show increasing interest in colours, as they may correlate with the health status or sexual readiness of the displayer, for example. We human do not necessarily see colours in the same way as our study organism; one should therefore consider the visual system of the receiver to make meaningful interpretations of animal communication. This shift in understanding brought a healthy dose of the sensory physiology of colour vision into behavioural ecology, insects being again very good models (Théry and Gomez, this volume). Thus, the interest in and need for dedicated work on the physiology of insect integument and colours is mounting and the future is bright.

Are we up to the task? It seems not, and the situation is getting worst. Take insect pigments, a notable and regrettable omission in this volume. More precisely, let us consider the different kinds of melanins. Melanins are being studied intensively, by many different groups of scientists, most of them related to human health. Ecologists, too, are proposing theories regarding melanin, including on insects, and carry out studies with melanin bioassays run on a routine basis. The number of excellent recent reviews on the mechanisms of melanin production and melanin physico-chemical properties is large and increasing rapidly (see Meredith and Sarna, 2006, or Simon *et al*., 2009 and references therein). None is, however, coming from entomological quarters, despite important advances in relation to the control and use of melanins (see, e.g., Hiruma and Riddiford, 2009).

The melanins are not an isolated case, as shown in another example, the ommochromes (Nijhout, this volume). This pigment class is present in nearly every insect, as a light barrier in the eye (latest references in Insausti and Casas, 2008, 2009). Many arthropods use it for yellow, red or brown colouration. Its biochemistry has been partially elucidated from the 1960s to the 1980s, culminating with many reviews and leading to the discovery of a new class of compounds, the papiliochromes. The prospects for profound work on the biochemistry and photoreactions of these pigments were excellent at that time. Indeed, several workers then hinted that there were potential biochemical links between ommochromes, pterines and melanin. Such prospects, which would have partially solved the incredibly complex matrices of pigment production and maybe animal colouration, were considered of sufficient importance to warrant publication in the journal *Science* (Bagnara *et al*., 1979). Why did this expertise nearly vanish two decades ago, just before the advent of molecular biology and gene silencing? Today, there is little activity on the chemistry, physics and biochemistry of ommochrome pigments, for insects or any other organisms. Many of those who worked on such pigments went into retirement. Those who are still in the science of photochemistry and photobiology of pigments have moved to other, related, substances of more promising applicability (e.g., in one notable case to bioactive-pharmaceutical anti-tumour compounds, which descend from the xanthommatin scaffold). The mainstream journal in the field changed from 'Pigment Cell Research' to 'Pigment, Cell and Melanoma Research' and now focuses nearly exclusively on biomedical issues. Newer techniques, even when adapted specifically for such difficult chemical groups (Vogliardi *et al*., 2004), are not even picked up by the community for later use—it is plainly too late, the community seems not to exist anymore. Is this work then obsolete, irrelevant? No. As a single example, the latest work on wing pattern development and on the sensory biology of colour vision of *Heliconius*, one of the most important butterfly groups for understanding mimicry, would greatly benefit from such knowledge (Briscoe *et al*., 2010; Ferguson and Jiggins, 2009; Nijhout, this volume). The same litany can be extended to functional morphology in general. The chapter of Gihradella (this volume) is indeed a reminder that a lot is still to be discovered by describing intriguing structures at a very small scale, on mites for example, and by asking basic questions about how and why such structures function as they do. In an age often described as the age of nanotechnology, functional morphology seems to be of highest potential value, but is in fact on the brink of extinction. France, for example, seems no longer to have a single academic position within its ca. 70 universities for a dedicated insect functional morphologist.

We think that the fate of insect integrative biology will be determined through the relative timing of two opposite and concurrent processes: the disappearance of skilled knowledge on one hand and the increased interest and dedication of sciences at a higher integrative level, most likely behavioural ecology *sensu lato*, on the other hand. A third process, molecular biologists moving up to physiology via systems biology, is also at play but might be too slow to reach such levels of integration. For us editors, the duty in the meantime is to keep the flame alive, by bringing like minds together and making their knowledge available such that it might inspire new directions of research in other adventurous scientists. The same spirit explains why we opted for having a chapter on protein sclerotization in marine invertebrates (Rubin *et al*., this volume): the findings are obviously highly relevant to insect biology and the expertise too scant to restrict its dissemination on the basis of (shifting) taxonomical boundaries.

We hope that this volume of *Advances in Insect Physiology*, too, contributes to the revival of insect integrative biology. Should you feel moved to suggest a thematic volume for the future that has similar aspirations, please feel free to contact us.

Acknowledgements

We warmly thank the referees who dedicated many hours checking large manuscripts. The work of J. Casas is supported by the Customized Intelligent Life Inspired Arrays (CILIA) project (FP6-IST-016039), funded by the European Community under the Information Society Technologies (IST) Program, Future and Emergent Technologies (FET), Lifelike Perception Systems Action, by the French ANR Project Blanc Physique 'Entomopter: The physics of flapping flight inspired by insects', and by a sabbatical grant from INRA. S. Simpson is funded by the Australian Research Council Federation and Laureate Fellowship schemes.

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