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Not dull to a dodo

ANDREW R. PARKER

Geoffrey E. Hill and Kevin J. McGraw, editors

BIRD COLORATION
Volume One: Mechanism and Measurements
544pp. 0 674 01893 1
Volume Two: Function and Evolution
477pp. 0 674 02176 2
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Around 150 million years ago, lizards began to evolve feathers with increasing aerodynamic efficiency until eventually they lifted off the ground. The immediate advantages of flight were to open up a whole new niche where airborne insects could be chased and ground-based predators avoided. Then came a secondary advantage – colour. Until this point, most terrestrial members of the chordates – the amphibians, reptiles and mammals – had tended towards camouflage. Drab browns, greys and greens were adorned to blend in with their surroundings and avoid unwanted attention. Indeed, with only dreary mates to look out for, mammals went as far as to lose their colour vision, condemned to a world of greys, though colour vision later re-evolved in the primates. But it would still have been advantageous to these squirrels and the like, for seeking the ripest fruit or spotting a predator's approach; and a colourful coat would have screamed "I'm over here" to a passing potential mate.

For many birds, taking to the air caused this delicate balance between conspicuousness and camouflage to tip the other way from that of mammals. The aim of *Bird Coloration* is to provide a flavour of the extent to which birds have exploited the sun's rays. Written as a review for undergraduate students and researchers, however, these two volumes also delve deeper into the disparate ways in which bird colours are produced, what purpose they perform, their effect on communities in general, and finally, how they got here in the first place – their evolution. It is not exhaustive, but that's probably just as well. So, at the expense of omitting some fascinating work, on fluorescence by the Brazilian André Nemésio, and egg-shell colour by Andy Gosler at Oxford, for instance, it does capture the diversity of its subjects and provides a much-needed review of the area. The reference lists alone are priceless. The editors, Geoffrey E. Hill and Kevin J. McGraw, begin their thankless task by tearing apart the complexity wrapped up in a composite subject, before the various experts perform their specialized analyses. By the end of the book, we are presented with all the ingredients, which we may keep independent or watch together to see the bigger picture, depending on our academic interests.

First up is the ingredient that colour does not exist – a paradox to set the tone for a virtual reality subject. There are two parts to this – the light that emanates from an object, and the organs that detect that light, or eyes. Light is electromagnetic radiation, displacing air molecules and travelling forward in the form of a wave. That is all; it has no colour. But radiation with high energy comes in waves that are shorter than those of low-energy radiation. Natural light radiation generally contains a range of energies, and so a wavelength hotch-potch strikes the eye. The retina of the eye contains pigments that respond differently to light of different wavelengths. A response triggers an electrical reaction that travels along the optic nerve to the brain. Finally, the brain is able to separate the signals from different pigments, and adds colour to them. So colour is a figment of our imagination, not the physical properties of light. This is where the film *The Matrix* found its storyline. If the optic nerve is intercepted with "designed" signals, the brain would interpret those signals and apparently we would see whatever was designed. So, in a post-apocalyptic world, one could see meadows and flowers, if that's what had been designed.

Unfortunately, all animals do not see the same picture. In other words, we don't see the world as birds see it. Most noteworthy is that birds have an additional pigment in their retinas that enables them to see ultraviolet, a colour to which we are blind. So there's a whole world operating all around us that we are

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absolutely oblivious to. A dull bird to us could actually be a flamboyant one, perhaps adorned with outlandish ultraviolet patterns. Clearly, to describe bird colours one requires equipment to detect, qualify and quantify the light waves behind them.

"Quantifying colors" is the title of Chapter Two. Here, the history of our recognition of and reaction to the above is summarized. We are told how to measure bird colours in the field and laboratory today using specialized spectrometers, which is useful to any researcher looking to spend around £5,000 or more. Professional graphics further liven the text. The next task concerns the interpreting of information gained on the waves that birds detect when they look at an object, followed by the effects of the light environment on an object's perceived colour. Sunlight, of course, contains more of the longer waves we perceive as red during the early morning or evening. Monet once painted the same haystack at midday and in the evening; the former was yellow and the latter orange-red. A straw-coloured bird feather would change similarly. But more interesting is the difference when sunlight, the source of illumination, appears in the form of a bright beam compared to one that is scattered by thick cloud cover or by leaves so that it illuminates a plumage from all directions. A bird of paradise dazzles only when sunlight arrives in a strong beam (which partly explains why British birds have not evolved such elaborate iridescence).

The next few fascinating chapters consider how or why light emanates from an object – how birds manipulate the sun's rays to provide the basis of colour. The colour-causing devices embedded within the skins and feathers of birds involve activity on a "nano" scale. Electrons can jump around within single atoms of pigments, or they can leap from atom to atom within a molecule, all at supersonic speeds. Then there are the microstructures that act like pinball machines, causing light waves to bounce around inside them. A hundred nanostructures adapted to cause a bright flash of green or yellow light could be lined up across the width of a single human hair. Not surprisingly, powerful electron microscopes are needed just to find the structures, and then the laws of optics can be applied to understand how they work.

The bustling, dynamic activities, albeit at a microscopic scale, fighting for the cause of their hosts' survival in the wavelengths they emit, are the final link in the colour chain. Now we have sunlight with its complete range of waves striking a feather, devices within the feather that re-emit some of those waves but not all of them, the eye that converts the emitted waves into electrical signals, and the brain that converts these signals into a colour picture. Further chapters cover how genes code for the pigments and structures that cause colour, and the functions of plumage colour in bird behaviour, including sexual selection and male aggressiveness.

The final chapter, however, is a bold one – an attempt to decipher, and reconstruct, the colour of extinct birds. This involves mapping the history of the DNA known to cause certain colours today onto the evolutionary tree of birds. This is risky since it considers only the most parsimonious routes and ignores the warning that closely related species today can contrast sharply in their colours. Still, it is a nice attempt to apply a scientific method to the subject. It is a pity that the Oxford Dodo was overlooked, however. Here is a case in which original, organic material from an extinct bird remains. Traces of a structure that causes blue coloration are preserved in the bill, and one that causes white in some feathers. Considerably older feathers are well preserved in amber. And the original pigments and colour-causing structures may have been preserved in rocks in the manner of the considerably older Burgess shale fossils. There is plenty of potential and excitement here.

Bird Coloration will appeal to students of, and researchers in, evolution in general, because the devices that cause colour are often considered as phenotypes. Those interested in ecology, animal behaviour and vision studies will benefit too. Feathers not only affect their avian hosts, but are spanners thrown into the otherwise simpler works of entire ecosystems. An iridescent red plume could trigger chaos among a backdrop of green, as local communities evolve adaptations to the powerful distraction of a periodic ruby flash. As hoped for in the Preface, this project should inspire other books to plug the gaps that remain in this subject, particularly where gene mapping is concerned. It may also attract other visually

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alert disciplines to nature's light – perhaps industrial chemists and optical engineers could find lessons and inspiration in the ways birds generate their often magnificent hues. Maybe the technology behind a hummingbird's flash could be transferred to jewellery, clothes, make-up or optical computer chips and anti-counterfeiting "holograms". And if further incentive is needed to buy these books, just flick through the colour sections.

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