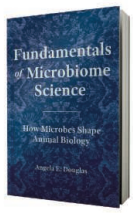
MICROBIOLOGY

Probing the microbial

A wide-ranging text synthesizes what we know (and don't know) about the microbiome

By **Fernando E. Vega**

Fundamentals of Microbiome Science
How Microbes Shape Animal Biology
Angela E. Douglas
Princeton University Press, 2018. 246 pp.



Angela Douglas is an internationally recognized expert on symbiosis, with a number of foundational texts to her name (*1*, *2*). In her new book, *Fundamentals of Microbiome Science*, Douglas synthetizes data from the burgeoning field of microbiome science in eight highly informative chapters. Topics include the origins of the animal microbiome, what we know about the microbiome's interactions with the immune system, hints at how microbes drive animal behavior, and how the gut microbiota are involved in gut-brain communication. The book also clearly delineates the influence of the microbiome in determining human health and disease.

The microbiome revolution is expanding at breakneck speed and moving from "the study of correlation to causation and mechanism." For example, mice lacking the leptin gene, which regulates satiety, consume more food and become obese. When the microbiota of obese mice are transferred to lean mice, the mice eventually become obese.

The reciprocal mechanisms involved in the interactions between the immune system and the microbiota are just beginning to be understood. In mammals, for example, the production of immunoglobulin A prevents contact of the microbiota with the epithelial cells of the gut, thus impeding microbe access to internal organs. Other innate immune effectors, including antimicrobial peptides, lectins, and certain enzymes, complement this effect, but many other factors (e.g., age of host, sex, and genotype) could also influence the outcome. The immune system can thus promote, tolerate, or inhibit the composition of the microbiota. In contrast, the microbiota can "promote or dampen immune system function," and the effects of microbial products on the regulation of immune effectors have been implicated in this process.

The book includes interesting studies on how the microbiome might influence complex processes, including circadian rhythms (e.g., the sleep-wake cycle), and mental health. One particularly interesting example is the possible involvement of *Bifidobacterium infantis* in mental health and, specifically, in the reduction of anxiety. When germ-free mice were subjected to restraint stress, their plasma titers of corticosterone and adrenocorticotropic hormone (stress hormones) increased, compared with conventional mice. The significantly higher titers were reversed when the germ-free mice were given *B. infantis*.

Grooming partners influence the gut microbiome of Amboseli baboons.

The microbiota have also been shown to influence animal communication and feeding behavior. Volatile carboxylic acids, for example, are known to emanate from the anal glands of many carnivorous mammals. These volatiles are the fermentation products of the microbiota that inhabit the glands and "play important roles in the social interactions of these mammals, including individual and group identity, territory marking, and recognition of mate and offspring."

Douglas discusses how signaling molecules produced by microbes may represent a possible mechanism in the regulation of feeding behavior but cautions that the current data are "far from conclusive." Similarly, she reveals that, although possible, "there is no definitive evidence" showing that the microbiota regulate the production of feeding regulatory molecules in the host. This kind of tempered analysis is one of the many strengths of this book.

In the final chapter, Douglas delves into some interesting and provocative topics and brings to the forefront the need to reframe our understanding of animals. Here, she includes a discussion of climate change and its potential effects on microbiota. A widely reported consequence of climate change is an increased range for animals into higher elevations and higher latitudes. How, Douglas wonders, will microbiota acquired in these new environments influence animals? This is an area in which "data are almost entirely lacking."

For many years, I have studied the microbiota of coffee plants and of the coffee berry borer, a small bark beetle considered the most important insect pest of coffee worldwide. Reading Douglas's book resulted in a cavalcade of new research ideas, an effect I have only very rarely experienced while reading scientific literature. How did the coffee berry borer and its microbiota coevolve? How does the insect acquire these bacteria and pass them on to its progeny? How do the microbiota differ between insects in cooler versus warmer coffee-growing areas?

Douglas has an encyclopedic knowledge of microbial systems, their ecology, and their metabolic functions with which she explains complex physiological mechanisms and identifies important research gaps. A summary at the end of each chapter succinctly recaps the preceding material, and 440 highly useful (but unobtrusive) references direct readers to the primary literature on which Douglas has based her claims. Dozens of figures elaborate on the complex concepts discussed in the text.

Overall, reading this book is a most satisfying intellectual feast. ■

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REFERENCES

1. A. Douglas. *Symbiotic Interactions* (Oxford University Press, Oxford, 1994).
2. A. Douglas. *The Symbiotic Habit* (Princeton University Press, Princeton, NJ, 2010).

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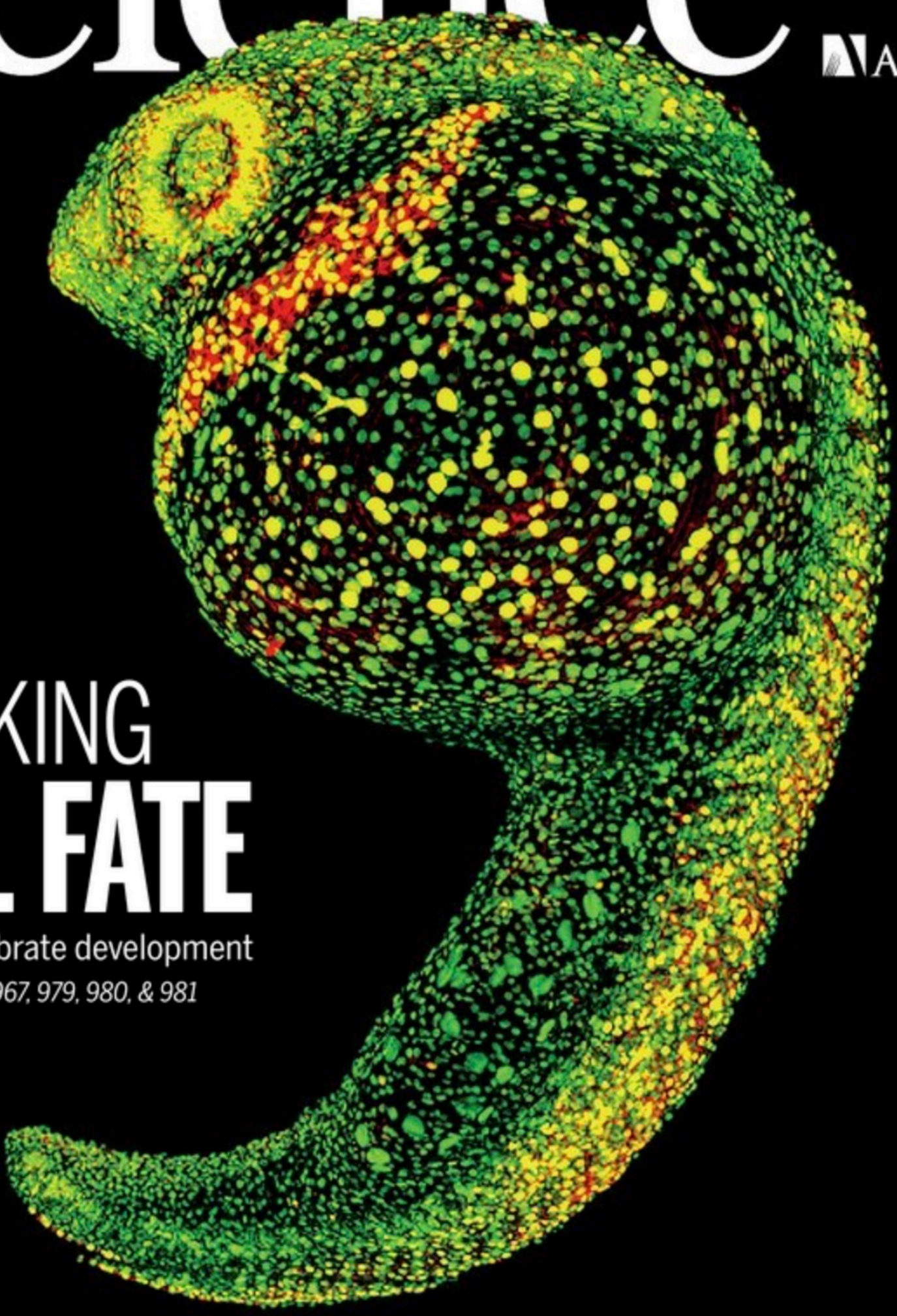

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