section on mechanisms of dominance. (I would have been happier if this chapter had been a little more closely tied to analysis in the previous chapter. There are serious insights into that languishing field quantitative genetics to be pointed up from the coagulation cascade and from interlocking metabolic pathways, both of which are discussed in chapter 4. But I am riding a hobbyhorse here.) There is also an unusual, but welcome, emphasis on genetics of embryogenesis.

The next chapters cover the three closely related topics of mutation, population genetics, and evolutionary genetics. Tastes differ, but I find the way in which these subjects are developed a little strange. The first of the three chapters treats point and chromosomal mutation together. But their dynamics and the means of detecting them tend to be very different, and estimating the rate of point mutation is heavily dependent on equilibrium arguments, which have their natural place in the following chapter. However, one cannot discuss everything at once, and I have never found an unexceptionable order of exposition. Inevitably in such a book, the treatment of analysis is deterministic (drift being dealt with in isolation in a separate section), and, while this is not altogether satisfactory, the most innumerate student cannot complain at any stage of being taken into deep waters. It is appropriate that the least reputable field of all, evolution, is treated separately.

In the last two chapters human genetics comes into its own. Chapter 8 deals with behavior, for once with attention to lesser animals in mazes appropriately subdued. Racial and cultural factors are addressed in a commendably low key. The last, all too brief, chapter deals with clinical and social issues concerning humans, now and in the foreseeable future. The nine appendixes deal with technical matters, mostly ancillary information on methods of analysis. The index is excellent.

As to my own field, mathematical genetics, I would not use the book to teach a course in the subject, although it would be a sound source for classical methods. I would have liked to see a somewhat more fundamental (not necessarily more technical) approach to problems. (For instance, map distance is *defined* in recombination fractions; there is confusion between linkage, which is a matter of assortment, and detailed gene assignment, which is anatomical; the careless reader is apt to overlook the authors' unobtrusive comments about the assumptions underlying the statistical tests used, which are widely misapplied.) There would also have been something to be said for presenting quantitative genetics not as a smooth and finished science but as one which has barely been started. It is encouraging to see the way the authors deal with noisy Mendelian traits, for instance; and they do an admirable, if compressed, job on the Galton-Fisher and Falconer models. But what if the effects of the components are not additive (as they are not in coagulation or where the law of mass action operates) or not even monotonic? There is little sense here that quantitative genetics is, or at least should be, a rapidly growing science. But these are minor flaws in a textbook as comprehensive as this one.

As to the areas I know almost nothing about, I shall keep them *in pectore*. But I have learned much by browsing and hope to learn much more.

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A Theory of Perception

The Ecological Approach to Visual Perception. JAMES J. GIBSON. Houghton Mifflin, Boston, 1979. xvi, 332 pp., illus. $18.95.

James J. Gibson had the breadth, insight, and stamina to mount and maintain a 50-year-long challenge to the establishment view of visual perception and offer a new vision in its place. Gibson was usually alone in his views and was rarely taken seriously by the establishment; his theories were often not even included in courses. His own rhetoric made it easy to brand his work as lacking in empirical relevance. And he was truly blind to the limitations of his theories, so he continually claimed more for them than he should have. But what he could properly claim is nothing short of revolutionary.

Gibson, who died last December at the age of 75, was at the height of his creative powers when he wrote this book, and it is a culmination of 50 years of research and theory building. It goes well beyond his two earlier books, frequently revising or updating central arguments of those works. Gibson's message concerns the laws of the science of perception and the way scientists have to understand them.

At a philosophical level, Gibson's ecological approach is a demand that those who study perception take into account both in their research and in their theories the natural visual environment in which perceivers live. While Gibson admits that our current theories might just barely be adequate to explain the perceiver's plight in the sterile visual world of the laboratory, he is forceful in showing how dissimilar the laboratory view is from the richness of information available in the real world. At the very best, from such study we might learn how to read during a lightning storm.

Gibson's most important criticisms are directed against the core of contemporary perceptual theory: that the retinal image as a two-dimensional display is the initial representation of information for perception of the visual world. The late Renaissance discoveries in optics, and especially the invention of the photographic camera, provided the model of light imaged on the retina just as it is in a camera. Given such a model, the problem then posed for perceptual theory is how this two-dimensional patterning of light can be transformed by a perceiver into a perception of three-dimensional space. Gibson shows that because the retinal image is not a picture there can never be reasonable answers to any of the important questions concerning perception when the problem is posed this way. He shows that we must focus our theoretical attention on the continuous stream of light coming to the retina in order to provide a proper description of the information being conveyed about the visual world. The fact that a frozen slice of the optical pattern of light bears some resemblance to a two-dimensional reflectance pattern of a surface reflecting light is a coincidence that must be ignored. Such resemblance is not even useful to explain perception of flat, two-dimensional surfaces such as pictures. Once one is willing to ignore this resemblance, or even to grant the possibility of ignoring it, the rest of the argument falls into place.

If information about the visual world is not contained in a pictorial image on the retina, then what are its sources? In answer to this question Gibson moves beyond philosophy and commentary on other theorists' work and specifies concrete and testable hypotheses. He provides both a detailed analysis of the way perceivers normally explore their visual environment and an analysis of that environment itself. Taken together the analyses comprise the ecology of the ecological approach to visual perception. Gibson's goal is to provide a description of all the sources of information about the layout of space as they are available to normal perceivers moving in their typical environments.

Normal visual exploration involves motion, so that the pattern on a retina from one moment to the next undergoes tremendous change. Therefore, the most important source of information about the visual world has to be the invariances, those aspects of the pattern of light that do not change as we move. It is the nonchanges that signify the stabilities of surfaces and objects in the world. Much of the book concerns the different kinds of invariances that specify stability, with rather complete descriptions of some and mere hints of others. These invariances in the flow of stimulation over the retinal surface, not frozen patterns on a fixed retinal picture, are the proper independent variables for visual perception.

The normal visual environment, as Gibson shows, is composed of scenes that begin under our feet and stretch toward a horizon. On that ground are objects, each with different surfaces of different reflectances and different textures. The scene is tied together visually by the ground. We simply do not spend much time looking at flat displays all parts of which are equidistant from us and no part of which is anchored to the ground. When we do, we have difficulty properly perceiving the true layout of that space.

The great virtue of recognizing the omnipresent ground is that the light reflected from it and from the objects attached to it provides a number of invariances over the full extent of the ground. No longer do we have to puzzle over explaining the size constancy of distant objects with their shrinking pictorial retinal-image size. Forget the image; ask instead what aspects of the pattern of light reflected from the ground and from objects at different distances are invariant. By asking this question Gibson is able to describe many invariants, especially ones that concern the ratios of texture density between the ground and objects resting on the ground at different distances.

This account cannot possibly stand for the whole thesis; it is only designed to suggest the dramatic departure the thesis represents.

Gibson does a magnificent job of describing the sources of information available to perceivers about the layout of space. But he fails to recognize that such a description is not a description of how that information is actually picked up and used to perceive the visual world. Available information is not equivalent to perception. To understand all of perception, we still need a theory of information processing to add to Gibson's description of the information itself. Although Gibson says that perceivers have to learn to attend to the invariances, he does not describe that learning process and, more critical, he implies that it does not need to be described. Here he is wrong, even in his own terms, for these are empirical matters, just as is the question of which of the available sources of information are most easily picked up for each type of perceiving situation. They cannot be decided by logic, geometry, or persuasion.

Gibson has shown that we have to throw away everything we thought we knew about the sources of information available for the perception of space. Although he has not shown how those sources are used to arrive at our perceptions, without his contributions we can never make further progress.

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(Continued on page 841)