source to specialists, a useful reference for teachers who wish to give students a sense of the natural technological wonders revealed by molecular genetics, and a reminder that long-established fields always remain capable of providing us with fresh insights.

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The Dyslexic Brain

Dyslexia and Development. Neurobiological Aspects of Extra-Ordinary Brains. ALBERT M. GALABURDA, Ed. Harvard University Press, Cambridge, MA, 1993. xxii, 378 pp., illus. $45 or £35.95. Based on a conference, Barcelona.

Developmental dyslexia is a widespread disorder, affecting some 5 to 10 percent of all children, adolescents, and adults. More boys than girls are affected, and there is convincing evidence that genetic and neurodevelopmental factors are involved. Dyslexia and other severe learning disorders may be associated with other developmental disorders such as language disturbance and attention deficit hyperactivity disorder, as well as disorders that implicate dysfunction of the immune system. They seem to occur more often in left-handed individuals.

Although dyslexia had always been presumed to be due to neurological dysfunction, evidence was circumstantial until Albert Galaburda published his postmortem studies of the brains of dyslexics, which provided convincing evidence of cytoarchitectural developmental abnormalities. *Dyslexia and Development*, containing contributions from representatives of the fields of neuroscience, neurology, neuropsychology, and genetics, goes far toward integrating the diverse literature exploring the neurobiological basis of this disorder.

As Barraquer-Bordas points out in the foreword, there has always been interest in comparisons of developmental dyslexia and acquired reading disorders of brain-injured adults. Although many of the symptoms are similar—such as the paralexias, or speech errors—dyslexia in children is not typically due to acquired brain damage. The first few chapters of this book explore the many neurobiological complexities that contribute to the developmental brain abnormalities first observed by Galaburda. As discussed by Finlay and Miller in the first chapter, experimental manipulations of the developing cortex in laboratory animals have improved our understanding of normal neurodevelopmental processes as well as likely patterns of brain reorganization after early brain insult.

Short of overt brain damage, however, what kind of early neurobiological environment might result in the brain anomalies that ultimately manifest themselves as dyslexia? In a very clearly written chapter Kelley discusses the possible role of the hormonal milieu during fetal development—in particular, testosterone, which influences the masculinization of tissues during critical neurodevelopmental periods. Androgen steroids may affect, both directly and indirectly, the commitment, proliferation, migration, differentiation, and survival of neurons. Kelley's hypothesis is that androgens' effects on brain cell number may lead to abnormal patterns of brain asymmetry in the language cortex, which might explain why males seem at greater risk than females for a variety of developmental disorders, including dyslexia. There is also evidence that histopathological alterations due to asphyxia may produce leptomeningeal heterotopias, which have also been observed in the brains of dyslexics and may play a role in development of the disorder, as discussed by Marín-Padilla. Rosen *et al.* point out that the brains of dyslexics are characterized by neuronal ectopias and symmetry of the region of the planum temporale. Drawing on the seminal conceptual work of Norman Geschwind, they argue that even focalized areas of cortical microdysgenesis can have widespread effects

Vignettes: Research Choices

People tend to stay away from the hypothalamus. Most brain scientists . . . prefer the sunny expanses of the cerebral cortex to the dark, claustrophobic regions at the base of the brain. They think of the hypothalamus—though they would never admit this to you—as haunted by animal spirits and the ghosts of primal urges. They suspect that it houses, not the usual shiny hardware of cognition, but some witches' brew of slimy, pulsating neurons adrift in a broth of mind-altering chemicals.

—*Simon LeVay*, in *The Sexual Brain* (MIT Press)

Biologists are always on the lookout for animals easy to rear in the laboratory, and what could be easier than cockroaches, which are usually there to start with anyway.

—*Howard Ensign Evans*, in *Life on a Little-Known Planet* (updated edition; Lyons and Burford)

that could contribute to the disorder.

Innocenti *et al.* and Hugdahl develop more fully the view that subtle brain alterations during fetal ontogeny can result in neurological and cognitive dysfunction. In particular, Hugdahl demonstrates how deviations in brain asymmetry and patterns of handedness may interact with immune disorders to produce the cognitive and behavioral deficits associated with dyslexia. Tallal and Fitch elaborate on hormone-mediated, gender-specific effects and their implications for the familial transmission of language and learning impairments. Njiokiktjien notes that developmental dysphasia and dyslexia have many common features and presents neurological arguments for a joint developmental dysphasia-dyslexia syndrome. It is in fact possible that dyslexia and perhaps other developmental language disorders as well are transmitted genetically. DeFries *et al.* provide a concise overview of behavioral and molecular genetic studies and note that although there is no consensus regarding a particular mode of inheritance, there is some evidence for linkage of a major gene for reading disability to chromosomes 6 and 15.

Neuroimaging procedures can enhance our understanding of the relationship between brain morphology and learning disorders, and Caviness *et al.* provide a concise review of the potential contributions of magnetic resonance imaging (MRI). Surprisingly, although the chapter provides valuable information about the morphometric applications of MRI—a field in which the authors have done pioneering work—it does not consider the recent imaging studies of the brains of dyslexics, which have been shown to exhibit functional and structural differences from those of nondyslexics.

This well-conceptualized and well-executed volume paves the way for further investigations of the neurobiological basis of a multifaceted disorder. It should be required reading for students and scholars in neuroscience, neuropsychology, genetics, and education.

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