Neurocultural Health and Wellbeing
Series Editors: L. Lorusso · B. Colombo · A. Porro · N. Wade

Amy Ione

Neuroscience and Art

The Neurocultural Landscape

Springer

Neurocultural Health and Wellbeing

Series Editors
Lorenzo Lorusso, Neurology Unit, A.S.S.T. Lecco-Merate, Merate, Italy
Bruno Colombo, DIMER, Neurologia, Ospedale San Raffaele, Milano, Italy
Alessandro Porro, Dip. di Scienze Cliniche e di Comunità, University of Milan Milano, Italy
Nicholas Wade, Department of Psychology, University of Dundee, Dundee, UK

Aim of this devoted book Series in neurology is to highlight the relationship between neuroscience and culture. Nowadays, there is more evidence of how our brain is influenced by the various artistic and cultural disciplines, both in the form of entertainment as well as – and above all – through the emotions and gratification which lead to wellbeing. The emotional mechanisms, the different cultural manifestations provided, are due to the activation of a perceptual and cognitive range that constitute the basis of the social behaviors. All this makes us aware of the benefits the arts have on personal and collective health.

This concept was already known to philosophers in ancient times, who were convinced that inner balance was influenced by culture and in particular by music.

During the centuries, men understood that the *cultivation of the spirit*, or *humanitas*, had a certain role on behavior and from the beginning of modern experimental science, in the fifteenth, the spread of the notions of neuroanatomy allowed artists to get closer to the knowledge of the brain's mechanisms and reveal the emotional and empathic responses at the basis of creativity, and indeed of their own psychophysical wellbeing. A dialogue between the science of the mind and artistic disciplines was born. The results of this meeting made it possible to better define which mental processes are involved when we come into contact with the various humanistic disciplines, and how they can be applied, for instance, to the treatment of mental disorders and neuropsychiatric diseases.

The goal of this Series is both to prove the role of biological brain mechanisms and the influence of various artistic forms on clinical practice, especially in neuro-psychiatric disorders, as well as to trace different therapeutic and psycho-physical well-being applications based on scientific evidence from medical literature.

Volumes of the Series will be edited by experts under the supervision of an international editorial committee. Each book, focused on a specific discipline, will provide knowledge on relationship between the brain activity and different forms of language, communication, art. This close inter-relationship with specific focus on different forms of art will explain the effectiveness of this kind of approaches in neuro-psychiatric diseases.

This Series will allow to understand how the culture is one of the fundamental tools to improve general well-being, quality of life and motivation in neurological diseases.

This Series also find a correlation with SDG3 goal "ensuring healthy lives and promoting wellbeing for all at all ages" for the progress of the health and wellbeing considering that neurological diseases are on the rise worldwide including in the developing countries.

Amy Ione

Neuroscience and Art

The Neurocultural Landscape

Springer

Amy Ione
The Diatrope Institute
Berkeley, CA, USA

ISSN 2731-4464 ISSN 2731-4472 (electronic)
Neurocultural Health and Wellbeing
ISBN 978-3-031-62335-6 ISBN 978-3-031-62336-3 (eBook)
https://doi.org/10.1007/978-3-031-62336-3

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2024
This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

If disposing of this product, please recycle the paper.

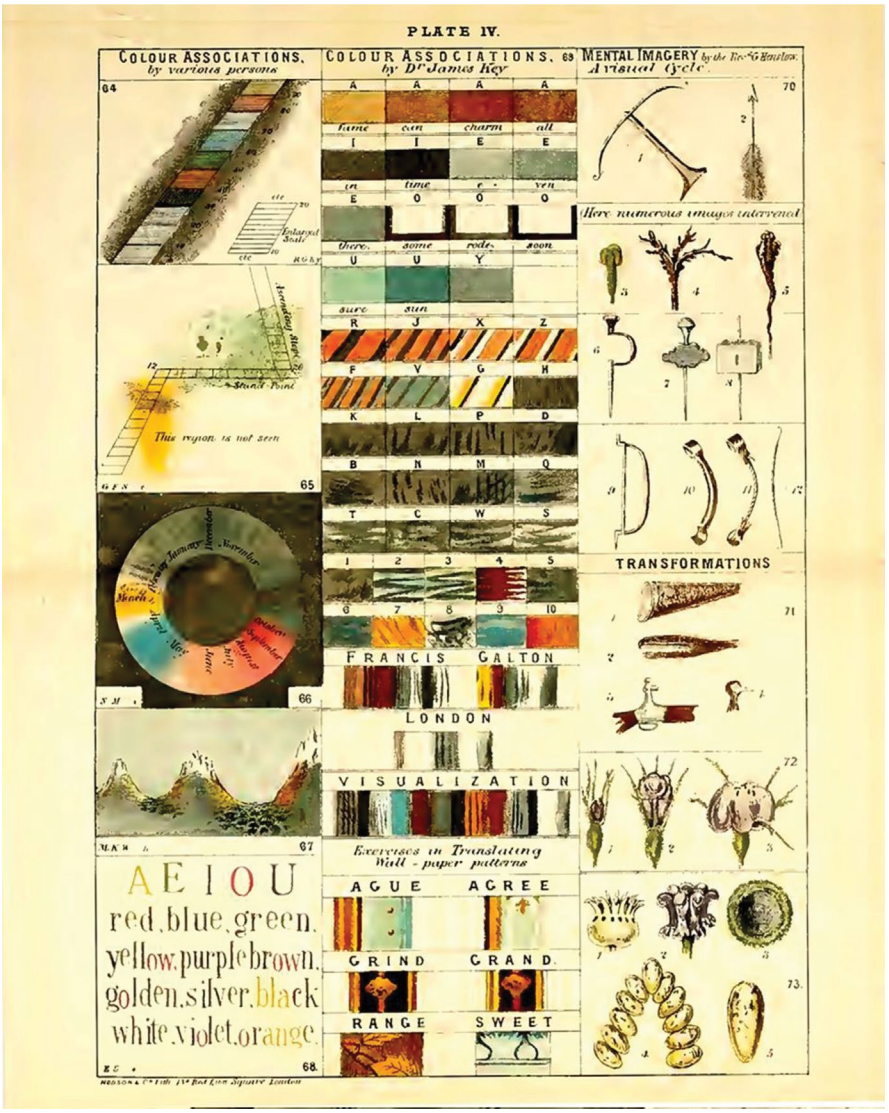

Plate IV from Francis Galton's *Inquiries into Human Faculty and Its Development* (1883). This compilation is an abridged summary of Galton observations on mental imagery. This book brought what we now call synesthesia to the attention of the scientific community

In Memory of Dame [Jean] Iris Murdoch (1919–1999) whose thought-provoking book The Fire and the Sun: Why Plato Banished the Artists first motivated me to think about the complexity of art and culture many years ago.

And

For Christopher Tyler, whose stimulating mind encompasses both an expertise in neuroscience and a knowledge of art that has become an intrinsic part of this book's texture.

Preface

Understanding ourselves as humans is incomplete without considering both biological and cultural aspects. In this book, the neurocultural perspective reflects how everything in the world is filtered back and forth between the brain and the cultural milieu. The thrust of the book, therefore, is to explore the power of art in creating a bridge between cultural and neuroscientific lines of inquiry. Looking at both clinical and non-clinical populations, the text examines historical foundations, distinguishes congenital/developmental conditions from those that are acquired, and emphasizes how the brain constructs our sensory experiences. Topics include the value of case studies, film, war's impact on medicine and art, therapeutics, and education. A range of conditions are integrated, such as prosopagnosia, synesthesia, autism, Alzheimer's disease, and so forth. Artists from all genres are incorporated. Among them are Iris Murdoch, Ludwig van Beethoven, Leonardo da Vinci, Cristoforo de Predis, Rembrandt, Federico Fellini, Chuck Close, and David Hockney. This book will be of interest to a broad range of clinicians and neuroscientists as well as those in the arts and humanities in general.

Berkeley, CA, USA — Amy Ione

Acknowledgments

Many thanks to Andrea Ridolfi and Smitha Diveshan at Springer for their help and guidance while I was organizing and writing this book. Thanks are also due to the many museums, organizations, and individuals who provided free access to images in their collections. I am among the many who appreciate this move toward increased image accessibility. Thanks, too, to all those who have contributed thoughts and ideas from the beginning. There are too many to name, but I would like to single out Lorenzo Lorusso and Christopher Tyler for their encouragement.

Contents

About the Author

Amy Ione is the Director of The Diatrope Institute, an organization for the dissemination of interdisciplinary information. She is a writer, artist, and educator and has studied the extensive linkages between art and neuroscience for over 30 years. She has published several books, including *Innovation and Visualization: Trajectories, Strategies, and Myths*; *Art and the Brain: Plasticity, Embodiment, and the Unclosed Circle*; and *Nature Exposed to Our Methods of Questioning*. *Neuroscience and Art: The Neurocultural Landscape* is her sixth book. Amy had also published over 200 articles and book reviews on art, neuroscience, technology, and cultural issues. In addition, Amy Ione is a lifelong artist, with artwork commissioned by the City of San Francisco, exhibited internationally, and found in many collections.

List of Figures

Part I

Overview

Historical Neuroculture

1

1.1 Why a Neurocultural Perspective?

Why write a book about neuroscience and art from a neurocultural perspective? The obvious reason is that understanding who we are as humans is incomplete without considering the interplay between biological and cultural perspectives, or neuroculture. Neuroculture in this book is addressed along the lines mentioned by Oliver Sacks when explaining his approach to neurology. From childhood he gravitated to medicine in part because he learned to see it as the study of stories of people. Each evening at the dinner table his physician parents talked about the patients they had seen during their day. This interest in the patient as an individual followed him to medical school and eventually led him to share the stories of lives impacted by disease or injury, conveying the uniqueness of each person in the process [1].

Neuroculture includes this comprehensive view of human health and well-being as seen through the profile of each individual. On the following pages, this spectrum is examined through neuroscientific research and a range of art forms that demonstrate the value of the arts. The arts are adept in communicating our joys and sorrows. They may tell a personal story or show declining health. They also record family interactions, social matters, and the indescribable. Syntax varies among the arts, just as intentions in making art do. Indeed, art may be expressive, therapeutic, challenging, uplifting, or defy characterization. Because the production, enjoyment, and value of art includes more than "art as beauty," we all benefit from comprehensively acknowledging the degree to which art and the brain interactions encompass all aspects of the complex human experience.

In his book *Musicophilia* [1], Oliver Sacks spoke to this point from another perspective when he noted that music was always one of the first things he looked up in any new neurology or physiology textbook. He adds that he developed this habit because he could scarcely find any mention of the subject until the 1977 publication of *Music and the Brain* [2] edited by Macdonald Critchley and R. A. Henson. Sacks hypothesized that one reason for the earlier scarcity of musical case histories was

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2024

A. Ione, *Neuroscience and Art*, Neurocultural Health and Wellbeing,
https://doi.org/10.1007/978-3-031-62336-3_1

that physicians rarely ask their patients about mishaps of musical perception whereas linguistic problems immediately come to light [1]. This chapter explores the history behind this lacuna, as does the next chapter on experiment, theory, and applications.

Music and the Brain [2] documented a symposium Critchley and Henson assembled in 1972. In their introduction to the proceedings they note that participants, to their surprise, realized that this event was the first occasion the subject of music and the brain had been submitted to serious discussion by neurologists, although the sedative and even therapeutic effects of music had been referred to on and off since the pre-Homeric myth of Orpheus and Eurydice [2]. Elaborating on this historical vacuum, Henson acknowledges that musicians in effect filled the gap as they pursued and perfected their craft:

> There is a wealth of distinguished writing by neurologists on philosophical and literary matters, and music has fared ill by comparison.… Even Henry Head limited his work on music to observations on the effects of brain damage on musical functions, although he had a good knowledge of music and the intellect and imagination to make a major contribution.… musicians have rightly made their own studies in practical or applied neurology. Teachers have expounded their ideas on motor activity and voice production as they relate to performance, hitherto with little assistance from neurophysiologists. Others have recorded their views on memory, an area where neurological knowledge is enlarging and increasingly capable of helping the musician (p. 3, [3]).

Recent historiographical work has begun to fill this gap with coverage of a wide array of topics, controversies, and competing perspectives [4–9]. Therefore, at this time there are many resources for those who wish to go beyond the historical summary offered here.[1] In examining this topic neuroculturally, this chapter and the next demonstrate how our understanding of brain function, sensory input evaluation, and higher-order functions has changed over the course of time. For example, looking at older material allows us to identify assumptions that became implicit and how they were initially interwoven into the cultural fabric before they were superseded as new knowledge emerged. This kind of comparative analysis also allows us to better comprehend current understandings of brain functions, brain injury, sensory modalities, brain plasticity, and the brain/culture exchange. A key variable, often underemphasized, is that it was not always understood that the brain constructs our experience. In other words, even with less understanding than the limited understanding we have today about neuroscience and the arts, people understood that the body, the mind, the brain, and culture are connected. So, on an experiential level, it was known that listening to music, for example, is not just auditory or emotional, it is motoric as well—and adds to human experience.

Before I turn to this historical material, let me note that art in this volume is not defined as Fine Art or an aesthetic that operates on some kind of lofty plane. Rather,

[1] In earlier work I have offered detailed historical chronologies on intersections between art and the brain, including collaborative work between artists and medical practitioners that aided research projects (see [10–17]). I have also examined art in relation to the history of psychology, the mind, and the brain elsewhere (see [12, 18]).

art covers a spectrum. It is a form of communication; a tool used to foster health and well-being; a therapeutic tool; a creative and innovative approach to problem-solving or expression; and it is an array of language forms, for each medium uses its own syntax. It is static, like painting and sculpture. It is dynamic, like music and the performing arts. It is found in both popular culture and more refined venues.

Finally, a few words about the book's overall organization. The four chapters that comprise Part I offer an overview that sets the tone for the book. Chapters 1 and 2 introduce historical assumptions and distinguish them from our contemporary knowledge base. Chapters 3 and 4 take this further, distinguishing biological and genetic conditions from those acquired later life. Together these two chapters stress that although an acquired condition is clearly biological and possibly related to genetics or environmental factors, it often creates a rupture that distinguishes it from a condition one knows from birth and infancy. In other words, baseline matters.

Part II presents a series of individual and thematic case studies. It opens with two chapters that contrast the work and conditions of two storytellers, Iris Murdoch and Oliver Sacks. Murdoch, a novelist/philosopher and a cultural icon, invented stories. Sacks, a neurologist, introduced the narratives of his patients to a larger public. Their health challenges and derivatives further frame each in terms of their inspirations, aspirations, and accomplishments. The case studies presented in Chapters 7, 8, and 9 offer thematic neurocultural examinations. Topics include technology, war, and therapeutics. The closing chapters that comprise Part III focus in on practices. The thrust encompasses both how individuals learn about and/or translate specific neuroatypical conditions and also covers how novices, specialists, and the atypical differ.

1.2 Why History Matters

History shows that seeking to comprehend life's complexity biologically and culturally has long roots. People have always asked who am I, what is nature, and how do we best live together? The "answers" have touched on ways of healing the ill, how to teach social mores to the community, and the development of communication tools such as language, art, music, and the performing arts. Within this, the loss of biological function and the preservation of well-being were always of great concern—and loss was interpreted as something that needed understanding, compassion, and cure to the degree possible. Thus, throughout time people have responded to health challenges, body changes, and mishaps by investigating the onset of illness or injury; just as they have found ways to enhance sensory experience and community.

We can identify investigations across the globe, even rudimentary work in ancient times, that included studies of the how the body works, surgeries to heal it, and pharmacological methods that were developed from the testing of crude extracts of plants, animals, and minerals for their medicinal properties [4, 6, 9, 19]. We can also identify experimentation and discussion regarding healthy living and education. We additionally find that in earlier times the neuroatypical and those with congenital

anomalies had fewer developmental prospects than those with acquired conditions, a point expanded on throughout this volume.

Art, too, was a part of the human equation. This is shown by a recent discovery of prehistoric bone and ivory flutes from the early Aurignacian period of southwestern Germany. These instruments affirm there was a musical tradition when modern humans colonized Europe, more than 35,000 calendar years ago [20]. Painting, like music, is found historically, as the known Cave Art throughout the world and extending back 40,000 years reminds us. Singing, a musical behavior that leaves no physical trace behind is no doubt a part of this history too for we see it depicted in ancient visual artwork. And surely the universality of beat perception would have given people the urge to move when their instruments were played, even among those listeners who were only minimally musical.

Although non-western lines of thought are largely outside the scope of this study, some are mentioned briefly in this chapter to underscore that not only were physiological functions and healing methodologies debated within cultures, but we can recognize them across cultures as well.[2] What I want to first stress here is that interpreting the earliest known cultural paradigms is challenging for us today due to the difficulty in separating magic and religion from clinical and experimental science in the documents and artifacts. Source materials that have survived do nonetheless offer a wide range of clues.

1.3 Egypt

In Egypt we can find evidence of sophisticated efforts to understand neurological conditions recorded in the *Edwin Smith Surgical Papyrus* and the *Ebers Papyrus* [6, 24]. These date from about 1500–1700 BCE, with the *Smith Papyrus* considered the older of the two. Several of the cases discuss the brain, meninges (coverings of the brain), spinal cord, and cerebrospinal fluid. Some include head injuries. From their descriptions we can see that the Egyptian physicians were aware that symptoms of central nervous system injuries could be felt far from the locus of damage [4, 6]. We also find sensory discussions. For example, in the *Ebers Papyrus* we find the earliest mention of deafness and otology on the list of medical remedies and spells against common ailments, which includes "the ear that hears badly." This suggests a loss of hearing rather than congenital deafness. The Egyptian notations about acquired deafness are also worth noting because congenital conditions were considered more puzzling than acquired ones,[3] as was the case in many cultures of the time.

[2] There is a growing body of work that looks comparatively and/or at other cultures (see [19, 21–23]). This interdisciplinary approach is important because it emphasizes the need for understanding human populations on both biological and cultural terms.

[3] Throughout this book deafness and loss of hearing are frequent topics. Therefore, it is important to note that people belonging to the Deaf Community do not consider deafness to be a disability and embrace the values upheld by the cultural model of Deafness [25].

Cited among the recorded observations we also find many eye problems even as far back as the *Ebers Papyrus,* again reinforcing that the Egyptians were keen observers. But, here too, there is no sense that they associated the retina with the optic nerve, for instance (see Fig. 2.5). Their documents do affirm they could, and did, observe the loss of visual perception and obvious biological degeneration or injury. Notations like a white opacity in the cornea of the eye show they could likewise identify physical symptoms of ailments such as leucoma, cataracts, and glaucoma. This is also evident from the cataloged treatments for eye diseases, although in many cases, the treatments themselves appear questionable (like using urine as an eyewash) [4].

The documentation makes it clear that ancient physicians were good observers but did not have enough information to consider healing and diagnostic options to the degree possible today. Obviously, they lacked the kinds of imaging tools we now have that allow us to see through opaque bodies and view brain processes. They also lacked any quantitative sense of electrophysiology, biochemistry, and the kinds of data we are beginning to accumulate on genetics, mutations, and the impact of environmental factors. Still, congenital abnormalities and "freaks" were catalogued, giving the impression that they saw this as a way to study them [26].

Along with the questionable treatments and diagnostic observations, we can also identify an array of other correct and incorrect assumptions. One frequently mentioned in neuroscientific histories is the Egyptian assumption that it was the heart, not the brain, that was the seat of perception, intellect, cognition, memory, and emotions. Indeed, like many Biblical and early Greek thinkers, we find the heart elevated over the brain in China, India, Egypt and throughout the world. Therefore, the heart was regarded as the spirit and soul of an individual. Phrases like "in my heart I know it's right" still reflect this way of thinking. Plato's tripartite theory of the brain is an exception here, although this in no way means all his ideas were error free. As discussed in Chap. 5, he had little regard for knowledge gained through our senses, although we know that our sensory system gives our brains knowledge about the world external to ourselves.

The importance of sensory experience in an individual's life was captured in an emotional response to blindness penned by an Egyptian painter Poi (c. 1304–1237 BCE) in a letter to his son. Poi's despondency over his vision loss shows that the despair that accompanies losing one's ability to see was as real then as now.

> Do not leave me. I live in despair … I live in darkness. My god Amon has left me. Bring me honey for my eyes, and fat … and genuine eye-paint, as soon as possible. Am I not your father? I wish to see, but my eyes are deserting me (p. 65, in [4]).

Artifacts and works of art additionally document maladies outside of the preserved medical literature. These, too, offer information about illness, health, emotions, and cultural views on well-being. When abnormalities and ailments are recorded, it is often unclear if the intention is to present symbolic ideas or if these serve as another example of how frequently cultural ideas are interwoven with views on biological change. Perhaps both.

Fig. 1.1 A mural of a blind musician playing a harp, from the tomb of the ancient Egyptian scribe called Nakht. c. 1422–1411 BCE. Courtesy of the Yorck Project

The blind Egyptian harpist (Fig. 1.1), a common motif in Egyptian art, also reminds us that the meaning behind an artifact is often unclear or symbolic. These musicians are generally represented singularly as a wealthy, well-dressed, bald, fat man. The harpist's baldness associated him with priests who shaved their heads to achieve ritual purity. The difficulty in dating the songs precisely matches the difficulty in interpreting the songs and the paintings. When Lichtheim studied the harpists' songs in the mid-twentieth century, she concluded they reveal the history of Egyptian attitudes toward death and the afterlife [27]. Since none of the harpist songs mention blindness, the inference is that the motif is purely symbolic, one intended to urge people to enjoy life on earth and stress the good to come in the afterlife, as the following refrain preserved in two New Kingdom documents conveys.

> He is happy, this good prince!
> Death is a kindly fate.
> A generation passes,
> Another stays,
> Since the time of the ancestors (in [27]).

Debates as to what artistic works like the blind harpist say are not confined to their symbolic aspects. They also demonstrate that the brain interprets many factors when engaging with art, including the syntax of the presentation. In this case, the painter's syntax includes pigments, color, line, form, and so forth to convey and capture this

work's message, which may include representations of higher-order symbolic ideas or abstract concepts that are culturally known, as it appears the blind harpists do. In linguistics, such as the poetic words comprising the harpist's song, we see another kind of syntax. Here words and morphemes are combined to form the language the brain interprets and by extension the abstract and symbolic ideas conveyed through it. Musical syntax would include pitch, notes, rhythm, melody, harmony, texture, timbre and so forth. Perhaps this song was read or sung with inflections that added a musical nuance to its linguistic, visual, and symbolic rendering?

1.4 The Ancient Greeks and Etymology

Ruminations on how the mind, the body, and nature functioned as a whole were also passionately discussed in Ancient Greece. From Pythagoras (c. 570 BCE–c. 500 BCE) and Thales (fl. 550 BCE) onward, thinkers and physicians were developing elaborate theories. One acknowledgement of the Greek contributions is found in current terminology that connects neuroscience and art to later fields of inquiry in the West. For example, the Greek term *psyche* (spirit or mind) later served as the root of psychology and psychiatry, two areas defined as stand-alone fields in the nineteenth century. Other terms associated with neuroscience and art that have Greek roots include neurology and aesthetics. Both are discussed shortly. *Therapeutikos*, the Greek root for therapy, means to cure or treat medically [28]. Therapeutics is the focus of Chap. 9.

The use of Greek etymology emphasizes how directly Western assumptions about the mind, the brain, and culture trace back to many Greeks ideas. Yet, it is important to note that despite some theoretical connectedness, the Greek worldview was intrinsically unlike our own, or even that of the Renaissance. How their cosmobiological assumptions differed is largely overlooked when discussing their impact on neuroscience and art [18, 29], and thus important to note.

A cosmobiological view is one in which everything is seen as a connected biological system. As the influential etymologist Henry Watson Fowler points out, both the words physics and physiology are derived from the Greek work *physiologia*:

> [*Physiks* and physiology] have now been narrowed and differentiated, physics retaining only the properties of matter and energy in inorganic nature, and physiology only the normal functions and phenomena of living beings (p. 427, [30]).

Physiologia, of course, is the root of physiology. When Jean Fernel (1497–1558), a sixteenth century French physician, introduced the term "physiology" to describe the study of the body's function, he said, "Anatomy is to physiology as geography is to history; it describes the theatre of events" (in [31]). When the term is used today to characterize how our bodies work, the term does not encapsulate the degree to which we live in a more bifurcated or specialized world than the Greeks, although theoretical conjectures surrounding it may. For the Greeks, however, physics (inorganic matter ***and*** nature) and physiology (nature ***and*** the body) were seen not just as

working in tandem; they were seen as inseparable [18, 29, 32]. The vagrancies of mind, disease, and the inexplicable that appeared to violate the cosmic harmony were more of a mystery. How this seamless perspective was evident in the ever-changing world at-large was vigorously debated and influenced thinking about natural philosophy (medicine, science, and philosophy).

In other words, the Greeks, like the Egyptians, took a serious interest in how all things work, and work in tandem, even the quite mysterious congenital conditions, and even though their conjectures about human physiology were based largely on animal studies. Physicians and philosophers contributed to these efforts to understand life, where it came from and how it was lived. For example, Hippocrates studied chicken embryos. Aristotle classified animal species and considered whether they reproduced by means of eggs, spontaneous generation (i.e., in smaller species and insects) or viviparity [26]. The physician Galen, too, offered hypotheses. He asked whether the embryo came from the white or the yolk of the hen's egg. These kinds of investigations fostered speculation [26], particularly in regard to brain formation and function.

Another term derived from the Greeks is anatomy, the branch of biology concerned with the study of the structure of organisms and their parts. The word is derived from the Greek word for dissection. Early anatomical investigations echoed the cultural rubric that assumed the proper goal was understanding how to achieve harmony between the parts and the whole of organisms. Human dissection was controversial and forbidden by law so comparative analyses were made through animal dissections and vivisections [4, 6, 33]. Because dissection was frowned upon for religious, moral, and cultural reasons, physicians and anatomists instead relied upon knowledge gained from minor surgeries. Exceptions to the legal restrictions did occur as well, including the work of Herophilus (335–280 or 255 BCE) and Erasistratus (c. 304–c. 250 BCE). While at the Alexandrian Museum, they put together a tripartite brain theory that was more anatomically informed than Plato's and included beliefs, emotions, and desires. This later model was somewhat modified by Galen of Pergamon (130–200) in the second century [34], who is discussed shortly.

Arete, another Greek term, reflects how Greek cosmobiological cultural mores referenced functional parts (humans) within the whole (society and/or the cosmos). Although *arete* is generally translated into English as virtue, it is more ambiguous. Arete, like many Greek terms, was used in both the microcosmic and macrocosmic sense to convey how working with (or within) the proper functional mode harmonized the whole. The idea was that all of us and everything has a certain function that we are intended to perform for our common humanity to achieve excellence. It could be a skill or efficiency at a particular job. The arete of a doctor is different from that of a warrior. For a warrior, one's function includes dying in battle; just as a physician's function is healing.

Individual bodies were seen in similar terms. So, in health and well-being, limit and order were considered good. The well-being of the world (or its harmony) and that of every creature in it depended on a proper mingling of the elements of which it is comprised. With the proper mingling, all is in a state of *harmonia* [32]. We

repeatedly see the urge for *harmonia* in descriptions of nature and the body's functions. One well known contributor here is Aristotle (384–322 BCE), Plato's student. His writings explain that every part of the body is formed for a purpose and that function could therefore be deduced from its structure.[4] *Harmonia's* medical formulation—humor theory—is credited to Hippocrates of Kos (460–377, BCE) and also connected to the Pythagoreans.

The Pythagorean tradition is important neuroculturally given that Pythagoras' (c. 570 BCE–490 BCE) most striking and enduring discoveries were in the field of music [32]. Although in many ways a mystical sect, the Pythagorean's also distinguished themselves from other Greek philosophers through their emphasis on form and order rather than the nature of matter. In addition, some say that Pythagorean thought influenced Plato in developing his ideas about Ideal Forms and the immortal soul. Pythagoras is particularly relevant neuroculturally because he identified that the pitch of a musical note is in inverse proportion to the length of the string that produces it, and that intervals between harmonious sound frequencies form simple numerical ratios [37]. When Hermann Helmholtz (1821–1894) published *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (1863), as discussed in the next chapter, he referenced Pythagoras' contributions [38].

In addition, the Pythagorean idea of the music of the spheres or harmony of the spheres is still associated with his name, although the concept has various interpretations. In Chap. 12, when synesthesia is discussed, Pythagoras' influence is relevant again. At this point, his contributions are noteworthy in terms of medicine and humor theory because they influenced Greek thought overall. Indeed, his ideas about form and order flowed down through the ages, and were correlated with both music and the body through the idea of harmony:

> Pythagorean, ideas were still regarded as canonical throughout the Middle Ages and beyond… [in] the study of medicine. Limit and order are good, and the well-being of the world and of every creature in it depends on a right mingling (*krasis*) of the elements of which it is composed. It is then in a state of *harmonia*, the word which (in Greek as in English) primarily applied to music being extended to cover the whole field of nature. To the microcosm this doctrine was applied in the theory that bodily health was dependent on the rightly proportioned mixture of the physical opposites: hot and cold, wet and dry. If they are in a state of *harmonia* in the body, then, as the doctor in Plato's *Symposium* puts it, the most mutually hostile elements in it are reconciled and taught to live in amity: "and by the most hostile I mean the most sharply opposed, as hot to cold, bitter to sweet, dry to wet." This dogma of the importance of maintaining—or restoring in the case of sickness—the right quantitative relationships between opposite qualities became the cornerstone of Greek medicine, which started in a Pythagorean atmosphere with the work of Alcmaeon of Croton (pp. 38–39, [32]).

Work attributed to Hippocrates of Kos is also associated with humor theory, although his work is now seen as the compilation of research notes by a school of physicians

[4] Aristotle's three great books on biology were *History of Animals*, *Parts of Animals*, and *The Generation of Animals*. One fascinating part of his contributions is his diagram of the "ladder of nature" (*scala naturae*), demonstrating the breadth of his interests in the whole animal kingdom, plants, and inanimate materials [35, 36].