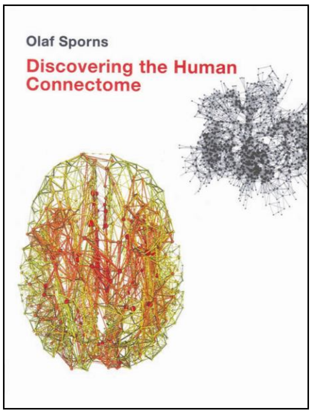


Discovering the Human Connectome. Olaf Sporns. MIT Press, 2012. 377 pp. Price: US$ 35. ISBN: 9780262017909.

This book by Olaf Sporns is an introduction to the emerging field of human connectomics, which endeavours to provide a comprehensive description of the network of elements and their interconnections that form the human brain, both structurally as well as functionally, at multiple scales (from synapses to large brain regions). Sporns is a pioneer in this field and provides a succinct account of the goals, challenges, and development as well as limitations of this emerging field.

The book has eight chapters. The first chapter highlights a strong connection between structure (anatomical architecture) and function in many biological systems, which motivates the endeavour to comprehensively map out the structural connectivity as a necessary first step towards generating a connectome. Sporns also provides a brief overview of different recording techniques for understanding structural and functional connectivity as well as computational methods, especially graph theory, which can be used to integrate data and study the structural properties across multiple scales in a principled way.

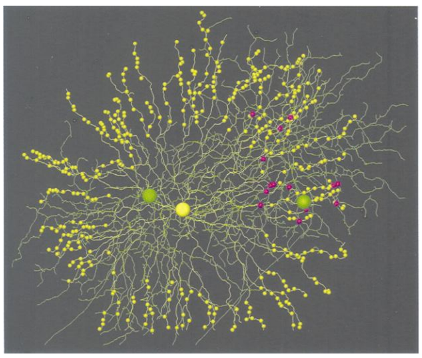
The second chapter describes the human connectome in more detail, and describes parallel efforts by several research groups to map out the structural connectivity in humans as well as other model organisms such as *Caenorhabditis elegans*. Sporns compares the human connectome to the already well-established Human Genome Project to emphasize the importance of deciphering the structural connectivity, at the same time insufficiency of only establishing a structural map without any insights about the functional connectivity. In addition to establishing the structure, Sporns identifies a second critical aspect of the connectome – network description, which allows a decomposition of the structure into meaningful elements and their relations.

The third chapter deals with the challenges towards establishing the human connectome. Sporns discusses three challenges. First, brain connectivity has a multi-scale architecture – ranging from dendritic compartments, neurons, microcircuits to system-wide networks, with no privileged scale that can be used as a reference point. Further, different scales interact with each other, with large-scale patterns emerging from small-scale networks, but most recording techniques characterize connectivity only at a single level. Characterization of connectivity not just within a scale but also across different scales is difficult. Second, there is individual variability of structural connectivity patterns – no two brains are exactly alike, even though this heterogeneity does not result in widely divergent function. This poses a difficult problem for approaches to connectomics at a microscale, which could potentially be resolved by the study of populations and quantifying the statistical variability. Finally, the structural elements and their connections are extremely plastic and are constantly remodelled – both spontaneously and in response to an external stimulus or global changes in the state of the organism. Taken together, these challenges make a study of connectomics below the level of a neuron (for example, at a level of spines and dendrites) almost unviable, and pose great difficulties even at larger scales.

The fourth and fifth chapters describe the techniques required to map the connectome at microscale (subcellular structures, including spines and synapses) and macroscale (small networks of neurons up to large brain regions) respectively. At the microscale, Sporns discusses techniques such as electron microscopy and light microscopy. At this scale, the image resolution is extremely high (down to nanometres using some techniques), and large volume of raw data is generated to image a small patch of neural tissue (presently in the sub-millimetre range). The real challenge lies in processing these raw data to obtain accurate maps of structures of interest and their interconnections. At the macroscale, tract tracing using a variety of tracers is employed to map long-range inter-regional projections, although its use is extremely limited for mapping the human brain. Magnetic resonance imaging, and in particular diffusion imaging, is a promising tool because it is non-invasive and relatively economical, and is applicable to individual whole brains. However, it also has limitations – for example, it only works in parts of the brain where the diffusion is anisotropic and consequently is unable to properly map the grey matter or unmyelinated axons.

The sixth chapter describes how the connectome shapes the dynamics of neural activity, and summarizes techniques used for mapping functional connectivity. Functional connectivity often has an underlying structural substrate, although the converse is not always true. Resting state fMRI done over relatively large time intervals has revealed functional neurocognitive networks, such as the default mode network. Statistical mining and graph theoretic analysis of such large-scale datasets have identified consistent and stable dynamic patterns, which transcend the relatively narrow bounds imposed by neuroanatomy. Sporns argues that the architectural feature of the human connectome, in particular the hierarchical modularity, must favour the emergence of flexible computation automatically, and therefore, the connectome can provide an intermediate link between anatomy and behaviour.

The seventh chapter describes the details of various types of network architecture that have been used to model the human brain. All human brain network studies show the presence of 'small-world' attributes, characterized by short path length (which indexes functional integration) and high clustering (which indexes functional segregation). In addition, the network hubs with a high degree are often inter-connected, thus forming a 'rich club' architecture with a central



core of highly and mutually interconnected brain regions within a modular small world. Some studies have shown that functional networks can exhibit critical behaviour, characterized by a mixture of randomness and order, which can potentially enhance information processing. Dynamic criticality is associated with hierarchical modularity, which is another hallmark of brain organization.

The final chapter describes the role of informatics and computation to model, visualize, analyse and interpret connectome data. Several model-driven as well as data-driven approaches are described that are being developed to build models of the brain such as the Blue Brain Project and the Virtual Brain that is built on a multi-scale theoretical framework. Sporns predicts that in the coming years connectomics as a field will expand rapidly, especially in generating shared large databases and developing network analysis tools and modelling. These will lead to a better understanding of brain dysfunction and disease, and could potentially be a phenotypic marker of an individual's behaviour and cognitive abilities.

The idea of generating a comprehensive structural map to understand functional properties of a biological system is not new – for example, the Human Genome Project is also based on the same ideology. The key question is how much can we know about the brain by a detailed study of the underlying structure, and what level of detail should we consider? Indeed, as the author elegantly points out, to describe the architecture of the great pyramid at Giza, a list of the dimensions and positions of the two million blocks of limestone would hardly be of any use. Connectomics goes beyond providing a detailed description of the structure, and emphasizes the development of hierarchical network models and mathematical tools to describe the complexity rather than using a brute-force approach. Recent advances in technology such as fMRI, super-resolution imaging, tract tracing, electrophysiology, EEG, MEG, etc. have led to the generation of large datasets, and specialized mathematical tools to interpret and extract useful information have become a necessity. The development of such tools is an important step towards understanding complex brain function as a whole.

Overall, this book will be of great interest to neurophysiologists and theoretical neuroscientists interested in understanding complex cognitive functions, properties of the brain architecture and various techniques and models used to study it, and to clinicians interested in the pathogenesis of brain disorders.

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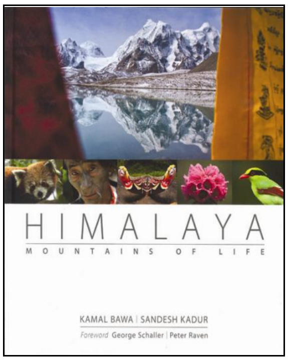

Himalaya: Mountains of Life. Kamal Bawa and Sandesh Kadur. Ashoka Trust for Research in Ecology and the Environment, Royal Enclave, Sriramapura, Jakkur Post, Bangalore 560 064. 2013. 305 pp. Price not mentioned.

The Himalaya is the youngest, tallest and amongst the most fascinating mountain ranges on Earth. It is a unique abode of biodiversity elements, large and small, from astoundingly enormous conifers and relatively medium-sized rhododendrons, elephants, brown bears and bearded vultures, to tiny invertebrates, many of which are endemic. The biodiversity of the Himalaya is remarkable at any scale, which has earned it the recognition of a global biodiversity hotspot. It is also an outstanding human cultural mix of varied ethnic and religious groups and people of different evolutionary and ecological histories. The immensity and complexity of life in the Himalaya are possible because of the size and peculiar geography of these mountain ranges. Through its sheer might, the Himalaya restricts the frigid Arctic winds to the north, thereby keeping South Asia warm, and drains the thunderous monsoon clouds to the south, thereby keeping the terais wet and the Tibetan plateau dry. With more than 15,000 glaciers, many of which are the starting points of important rivers, including the Indus, Ganga, Brahmaputra, Irrawady and their tributaries, it is a vast storehouse of freshwater that supports life over a million square kilometres downstream. The broad elevation gradient of the Himalaya goes from the low-lying outer flood plains and the Shivaliks to the inner Trans- and Greater Himalayan ranges, which are the tallest in the world. As a result, one can see the greater one-horned rhinoceros and giant hornbills in the alluvial flood plains and subtropical forests of the foothills, and the elusive snow leopard and delightful Apollo butterflies at mountaintops and in the Trans-Himalaya. The precipitation gradient also creates an interesting biodiversity gradient from east to west. Due to greater precipitation and proximity to Indo-China, the Eastern Himalaya is far more biodiverse compared to the Western Himalaya. The Western Himalaya also has more Palaeoarctic biodiversity elements (groups of plants and animals), whereas the Eastern Himalaya is dominated by the Oriental elements. On the whole, the Himalayan mountains are an outstanding phenomenon that has captivated geographers, hydrologists, biologists, spiritualists, pilgrims and tourists for hundreds of years. The magnificence, beauty and diversity of the Himalaya have now been captured in a large-format, superbly produced coffee-table book. It is a collection of expertly interwoven and wonderfully blended photographic stories of people, wildlife and landscapes. It is a product of the combined efforts of Kamal Bawa, an eminent plant evolutionary biologist and a pioneering conservationist, and Sandesh Kadur, a talented and accomplished photographer and wildlife film-maker.

The main strength, and the major attraction of the book, is its collection of stunning images of rare, endemic and

The Jerdon's Pit Viper is one of over 150 species of highly-evolved venomous snakes belonging to the subfamily Crotalinae which are distinguished by a deep pit, or fossa, in the loreal area between the eye and the nostril on either side of the head.