Atlas of Cytoarchitectonics of the Adult Human Cerebral Cortex

by

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and

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With full-scale reproductions of the original 112 microphotographic plates, including 8 tables, 33 figures, 4 in color

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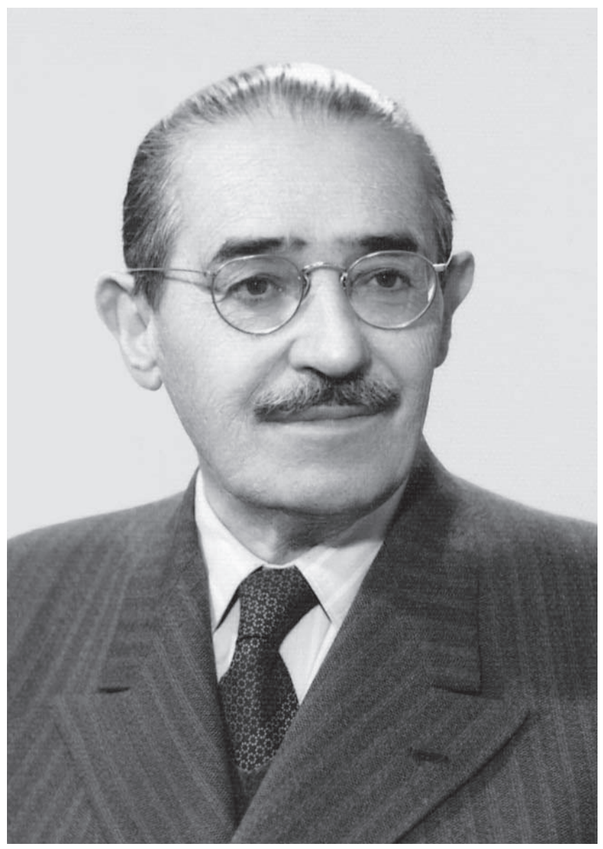
Contents



Begleitwort

Dieser *photographische Atlas* veranschaulicht die Cytoarchitektonik der wichtigsten Teile des Großhirnmantels. Hier sind auf 112 Tafeln die verschiedensten Stellen der Hirnrinde auf 134 Photographien wiedergegeben. 102 dieser Bilder, welche die wichtigsten Teile der gewöhnlichen Großhirnrinde darstellen, sind bei 100facher Vergrößerung dargestellt, so daß 1 mm der auf jedem Bilde angebrachten Skala 10 µm entspricht, so daß man durch unmittelbare Messung sich sofort über die Größenverhältnisse orientieren kann. Der Maßstab erlaubt, da er an drei Seiten der Bilder angebracht ist, nicht nur die Messung der Größenwerte, sondern auch die unmittelbar verständliche Orientierung und die Definierung eines bestimmten Punktes auf der Tafel, z. B. ein Punkt im Bilde in der Skalahöhe 20 cm und in der Skalabreite 15 cm ist durch diese Ordinaten vollkommen fixiert. Nur 32 Bilder, welche dem sog. Riechhirn entsprechen, bei welchem es mehr auf die allgemeine topographische Orientierung als auf die histologischen Details ankam, sind bei bloß 50facher, einzelne davon bei 25facher Vergrößerung dargestellt, was *bei jedem Bilde extra vermerkt* ist; hier entspräche also 1 mm = 20 µm, resp. = 40 µm. Sämtliche Bilder sind direkte photographische *Kopien* (*nicht* Phototypien oder Drucke!) von mikrophotographischen Aufnahmen und somit jedes Detail echt und ohne jede Zutat. Die aufgenommenen Schnittpräparate der Rinde waren *sämtlich* 25 µm *dick*, so daß der Zellgehalt, Zellgröße usw. der Tafeln untereinander verglichen und auch sonstiges unmittelbar richtig aus den Tafeln berechnet werden kann. Sie sind alle mit Zeiss, Planar, 2 cm Brennweite, aufgenommen, so daß die *ganze Tiefe* des Schnittes mit gleicher Schärfe und in allen ihren Elementen auf der Bildfläche zur Anschauung kommt, so daß unmittelbar auch richtige Zellzählungen an ihnen vorgenommen werden können. Wir glauben, daß die 100fache Vergrößerung, die wir nach vielen Versuchen gewählt haben, bei weitem die beste ist, weil sie ohne weitere Lupenanwendung jedes vom Planar aufgenommene Detail unmittelbar erkennen läßt und jede Messung bei dieser Vergrößerung sehr einfach ist. Für die *Schnittdicke* von 25 µm haben wir uns nach langen Versuchen entschieden, weil es die Schnittdicke ist, bei der einerseits noch die *Zelldetails* gut auftreten, andererseits die *Schichtenbildung gerade schon gut hervortritt*. Auf dünneren Schnitten gehen Änderungen in der Dichtigkeit und sonst im Bau der *Schicht* verloren.

Die aus dem Text hier wiedergegebenen Abb. 151a und b [Fig. 1] zeigen genau an, von welcher Hirnstelle jedes der hier photographierten Präparate entnommen ist. Auf jeder Photographie sind am Rande mit weißen Strichen die Grenzen der 6 Schichten angedeutet und ebenso die entsprechende Ziffer der Schicht mit römischen Zahlen eingesetzt.

Jede Tafel trägt ferner unten als Bezeichnung den Gyrus oder Sulcus, dem das Bild entspricht, meist mit einer näheren orientierenden Ortsangabe, ferner darunter das der dargestellten Area entsprechende Buchstabensymbol sowie den Namen der Area oder Areae; außerdem noch das Maß der linearen Vergrößerung.

Da wir nun auch die Textfiguren Abb. 92 und 93 [Fig. 2], unsere areale Hirnkarte der Konvexität und der Medianfläche des Gehirns, hier nochmals wiedergeben, auf welchen die Areae sämtlich mit ihren Buchstabensymbolen eingetragen sind, so ist man schon an Hand dieser 4 Abbildungen und der Photographien des Atlas ohne weiteres imstande, sich eine Übersicht über den Zellaufbau der ganzen Großhirnrinde zu verschaffen. Die näheren Einzelheiten müssen natürlich stets im Textbande nachgelesen werden. Zur besseren Orientierung in dem voluminösen Textbande geben wir hier auch nochmals ein ausführlich laufendes Tafelverzeichnis, auf welchem, wenigstens ungefähr, die Seiten des Textbandes angegeben sind, auf welchen die entsprechenden abgebildeten Areae besprochen werden.

Constantin von Economo, Georg N. Koskinas
Wien, im September 1924

Preface • Acknowledgements

It is a rare circumstance and an indescribable joy to present to the scientific community the first English edition of the *Atlas of Cytoarchitectonics of the Adult Human Cerebral Cortex* of Constantin von Economo and Georg N. Koskinas, one of the greatest – and rarest – classics in the neuroscience literature.

With this work, Economo and Koskinas defined their 107 cytoarchitectonic cortical modification areas for the human brain.

The original *Atlas* was published in German in 1925 in 100 sets. For all practical reasons, accessibility to the work has remained rather limited for the majority of basic and clinical investigators, discounting the case of certain connaisseurs, such as Gerhardt von Bonin, who adopted the Economo-Koskinas nomenclature in their own classical studies of the cerebral cortex.

At the time of publication, the *Atlas* was called monumental, a royal gift to science, a masterpiece unique in the international medical literature, its plates being brilliant achievements in scientific microphotography, and an entirely magnificent work that almost brings the study of the cerebral cortex to an end. It contained 112 microphotographic plates of 40 × 40 cm, all printed from the original glass negative plates on genuine photographic paper of 48 × 48 cm in size. It is from one such set that the present edition has been prepared, maintaining the original magnification of the micrographs.

The book is intended for basic researchers in neuroscience, anatomy and physiology, clinicians in neurology, neuropathology, neurosurgery and psychiatry, as well as for investigators in the fields of psychology, neuropsychology, brain imaging, cognitive neuroscience, neurolinguistics, evolutionary neuroscience, and neuroscience education.

An important point about the Economo-Koskinas *Atlas* is the definition of 107 cortical cytoarchitectonic modifications as opposed to Brodmann's 44 areas for the human cerebral hemispheres. Therefore, re-publication of the *Atlas* bears directly on modern research-clinical applications in the immediate future, beyond the resurrection of a fine piece of research of academic interest. With the added advantage of having being published 16 years after Brodmann's book, the Economo-Koskinas *Cytoarchitectonics* critically compared the 107 cortical subdivisions with Brodmann areas, as well as those of all preceding investigators.

We are currently at a crossroads in science, where psychology (let us not forget that *psyche* is a term of philosophical, rather than scientific, origin) is gradually leaning towards a functional neuroscience at systems and integrative levels. Cytoarchitectonic cortical structure reached a summit in the work of Economo and Koskinas, while knowledge on brain function is still evolving. Functional studies necessitate anatomical bases, and the Economo-Koskinas scheme offers finer grained maps of the cerebral cortex compared to the Brodmann scheme that has dominated the field for almost a century.

The essence of this new publication is best summarized in the following words written by Koskinas in 1931: 'We hope that our work could be used as a basis for future research, and that is why we have attributed a special significance to the presentation through images. We expound our views based on our photographic *Atlas*, which will form objective evidence for this new scientific field and will render anyone working on this topic independent of current notions and traditions, and therefore to a wide extent independent even of our own division of the cortex into areas.'

The book incorporates as appendix material new biographical notes on Economo and on Koskinas, and complete listings of their published works.

A cordial word of thankfulness is owed to my cherished professors Manuel del Cerro, Robert W. Doty, Leo G. Abood, Garth J. Thomas, Robert J. Joynt and David Goldblatt in Rochester, Bernardino Ghetti, Richard G. Peterson, Shirley A. Bayer, Sidney Ochs and William E. DeMyer in Indianapolis, Anders Björklund in Lund, José M. Palacios in Basel, and Guadalupe Mengod Los Arcos in Barcelona, for their valued precepts in Neuroanatomy during my graduate and postdoctoral years.

I express my sincerest gratitude to the Rights and Permissions Department of Springer-Verlag, Vienna, who had originally published the title, and Mrs. Angela Fössl in particular, for kindly giving us the 'green light' to proceed with a new edition of the work.

Publication of the *Atlas* has been made possible through generous grant support from the Bodossakis Foundation, Athens, the Hellenic Ministry of National Education, and the University of Macedonia, to all of whom I am most grateful.

I express my deepest appreciation to Dr. Thomas Karger and Steven Karger for preserving the tradition and the fine craft of biomedical publishing and for being adamant about abiding to the quality standards envisaged by Constantin von Economo and Georg N. Koskinas. I would like to express my particular gratitude to S. Karger Publishers for the first-class reproduction of the *Atlas of Cytoarchitectonics of the Adult Human Cerebral Cortex*, especially the many individual members of staff who I had the pleasure to directly co-operate with, but also the many other staff members who have contributed their service behind the scenes and thus enabled me to realize this project.

Lazaros C. Triarhou
Thessaloniki, January 2007

Foreword

This *Photographic Atlas* depicts the cytoarchitectonics of the most important parts of the cerebral cortex. The diversity of the cortical areas is exposed in 134 photographs, arranged in 112 plates. One hundred and two of the figures are representations of the most important parts of a typical cerebral cortex and are shown at ×100 magnification, i.e. 1 mm on the scale bar corresponding to 10 µm in the figure. This facilitates immediate orientation through direct measurement over relative proportions. The included scale bars, since they are appended on three sides of the figure,* permit not only measurement of size, but also direct perception of position and definition of a certain point in the field: for example, a point in the figure at a scale height of 20 cm and a scale width of 15 cm is perfectly defined by these co-ordinates. Only 32 figures correspond to the so-called rhinencephalon where general topographic orientation rather than histological detail matters most. These figures are shown at a magnification of ×50, some even at ×25, which is specially denoted on each figure – 1 mm corresponding to 20 or 40 µm, respectively. All of the figures are direct photographic prints from microphotographic negatives and thus each detail is genuine and without any retouching. The photographed sections of the cortex were all 25 µm thick to ensure that the cell content, cell size, etc. of each plate would be comparable with the others, and that additional data could be calculated directly from the plates. They are all taken with a Zeiss Planar objective, 2 cm focal length, ensuring that in each section the entire depth appears with the same sharpness and that their elements can be visualized in their entirety throughout the focal plane; direct correct cell counts may also be obtained from the images. We believe that the ×100 magnification, which we chose after many tests, is by far the best, because it directly shows each detail shot by the Planar without the need for further magnification. All measurements at this magnification are very simple. After thorough trials, we decided to use a section thickness of 25 µm. This would mean, on the one hand, that cell details are still discernible and, on the other, that laminar formation stands out. Changes in compactness as well as layer structure are lost in thinner sections.

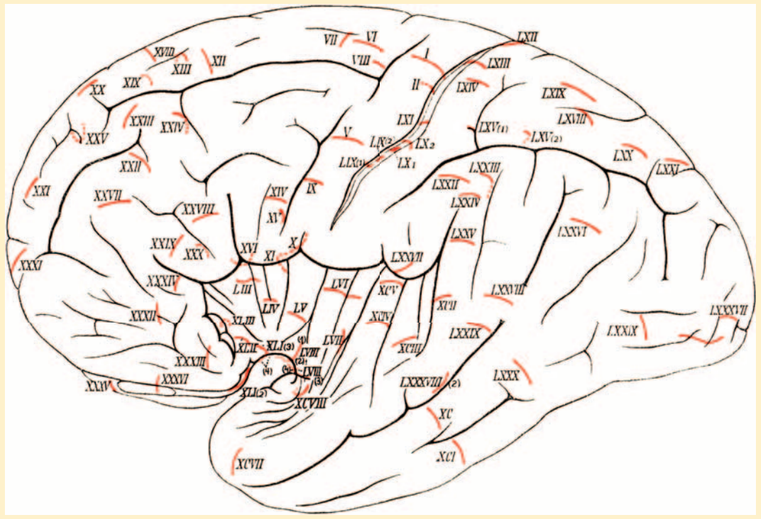
Figure 1 (reproduced from figures 115a and b of our text volume) indicates the exact brain area from which each of the photographed preparations was taken. The six layers and their appropriate layer numbers (in Roman numerals) are denoted on the border of each photograph.

Each plate depicts either a gyrus or a sulcus with the specific nomenclature of the exact position. Further, the appropriate letter symbol of the represented area as well as the name of the area or areas are shown. In addition, the value of the linear magnification is noted.

Figure 2 (reproduced from figures 92 and 93 of our text volume) shows the cortical area maps we made of the convexity and median facies of the brain, with all areas being depicted by their letter symbols. Thus, on the basis of these illustrations and the photographs in the *Atlas*, one achieves an easy overview of the cellular structure of the entire cerebral cortex. For more detailed information, one should of course refer to the accompanying text volume. In order to achieve a better orientation in the large text volume, a detailed list of the plates indicates the corresponding pages of the text (at least approximately) where the respective areas are discussed.

Constantin von Economo, Georg N. Koskinas
Vienna, September 1924

* [Editor's note: The rationale for using scale bars only on two sides of each plate for the present English edition is explained on p. 16 of this volume].



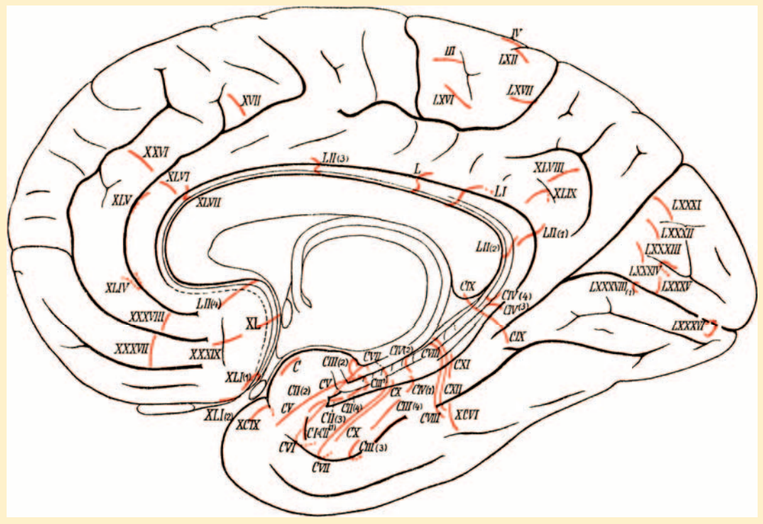
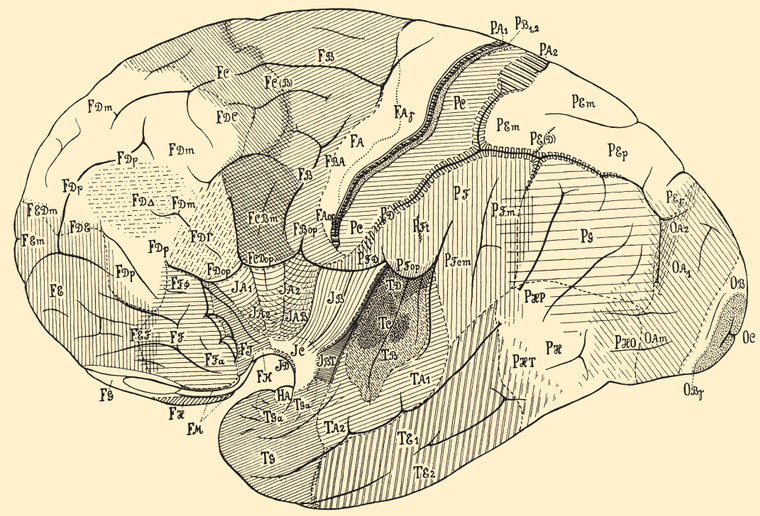


Fig. 1.

Topographic location of the sections from which the photographic plates in the *Atlas* are reproduced. The red lines indicate the plane of sectioning. Roman numerals indicate the number of the corresponding plate.



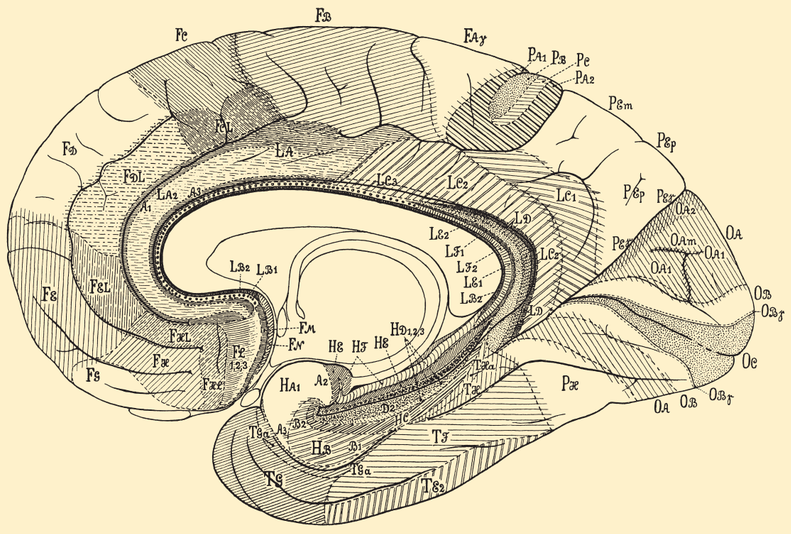


Fig. 2.

Brain map of the cytoarchitectonic areas of the convexity and median facies.