中国数字化可视人体图谱

Atlas of Chinese Visible Human(Male and Female)

张绍祥 王平安 刘正津 主编

Chief Editors

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科学出版社

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内 容 简 介

作者从完成的首例中国男性与女性数字化可视人体数据集中精选出部分图像进行人体解剖结构的详细标注，采用从头到足连续断面的形式展示人体内部结构在不同水平的变化规律。本书既可作为临床CT、MRI、PET等影像诊断对照的工具书、临床医师了解人体各部位详细结构的参考书、医学生学习人体解剖学等课程的教学参考书，同时，又是人体结构信息研究的基本图像数据资料。

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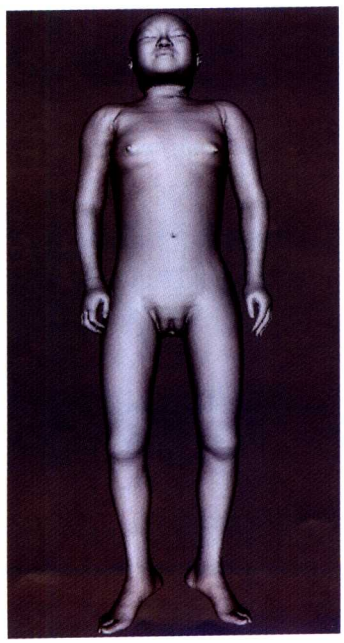
前　言

随着数字化时代的来临，与人体结构数据有关的医学、航天、体育、军事、汽车、机械制造、艺术等领域产生了对数字化可视人体的迫切需求。美国国家医学图书馆（NLM）抓住先机，于1989年提出了“可视化人体计划（Visible Human Project,VHP)”。1991年8月，NLM与Colorado大学医学院签署协议，由Colorado大学负责人体结构数据的采集和三维重构。Colorado大学的VHP课题组在V.M.Spitzer教授的领导下开展了卓有成效的工作。他们将人体标本低温冰冻后，用工业铣床逐层铣切并照相，输入计算机获取连续横断面图像，然后进行人体结构的三维重建。1994年11月，VHP课题组获取了世界上第一例人体结构数据集并予以公布。数据集采自一中年男性标本，共1878个横断面图像，相邻断面间隔1.0mm；每幅断面图像数字化扫描分辨率约为420万（2048 × 2048）像素，总数据量为15GB。1995年12月，该课题组又完成了一例女性标本的断面制作和图像数据采集：断面总数为5189幅，断面间距为0.33mm，总数据量达43GB。美国可视人计划引起了全球性的巨大反响。自1996年起，由NLM主持的VHP国际学术会议已举行了四届（1996、1998、2000、2002年）。数十个国家的众多用户与美国国家医学图书馆签订了数据集的使用协议。

不少研究机构或大学利用VHP的连续断面图像数据，已经或正在开发新的计算机人体模拟系统和实用产品，如华盛顿大学的数字解剖学系统、哈佛大学的全脑图谱及外科手术规划系统、斯坦福大学的虚拟内镜系统、德国汉堡大学的Voxel-Man系统、美国伦斯利尔理工学院的核医学虚拟仿真系统，等等。目前，韩国、日本、德国、法国、英国和瑞士等纷纷启动了可视化人体研究计划。其中，韩国可视化人体计划（Visible Korean Human,VKH）已取得了令人瞩目的阶段性研究成果。韩国Ajou大学医学院和韩国科技信息研究所获得国家科学基金资助，实施了韩国可视人五年计划（2000年3月～2005年2月）。2001年3月，Min Suk Chung博士领导的课题组获取了第一例韩国可视人体数据集：连续横断面厚度为0.2mm，断面数码摄影分辨率为610万（3040 × 2008）像素。标本来源于一名65岁的脑瘤患者。VKH正在按计划紧锣密鼓地开展后续研究工作。

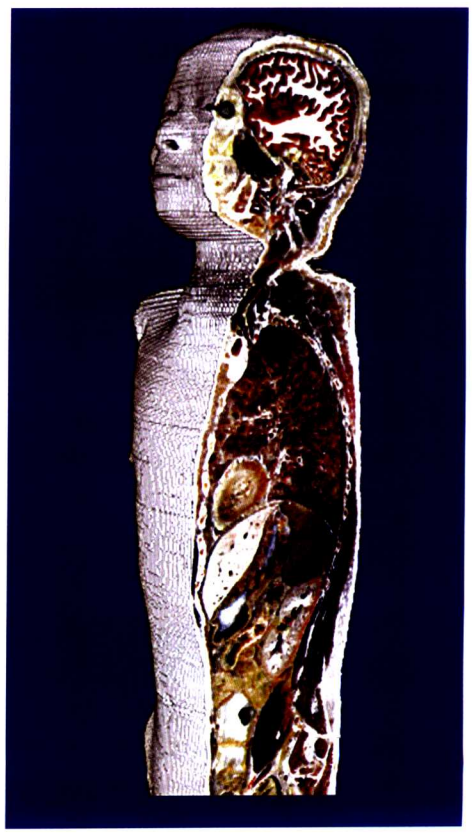


由于可视化人体研究在与人体形态结构相关的诸多领域具有重要的理论意义和广阔的应用前景，国内不少学者一直关注着这一领域的进展，并利用美国的VHP数据集进行了成效显著的探索性研究。第174次和208

次“香山科学会议”专题研讨数字化人体的科技问题。这些工作为我国数字化可视人体的研究奠定了基础。

我们课题组从1985年开始从事人体断面解剖学研究，1990年以后，致力于人体薄层断面影像解剖学研究。1999年，获得国家杰出青年基金资助，开始进行建立中国人体结构数据集的研究。经过近4年的艰苦工作，分别于2002年10月和2003年2月完成了中国男性和女性数字化可视人体（Chinese Visible Human，CVH）数据集的采集。男性标本及数据集有关指标为：35岁，身高170cm，体重65kg，非器质性疾病死亡；头部和颈部连续横断面层厚为0.5mm，其中颅底部为0.1mm，其他部位为1.0mm，全身共计2518个横断面；数字化摄影分辨率为630万(3072 × 2048)像素，每个断面图像文件大小为36MB（.tiff格式），整个数据集数据量为90.65GB。女性标本及数据集有关指标为：22岁，身高162cm，体重54kg，非器质性疾病死亡；头部和颈部连续横断面层厚为0.25mm，其他部位为0.5mm，全身共计3640个横断面；数字化摄影分辨率为630万(3072 × 2048)像素，每个断面图像文件大小为36MB(.tiff格式)，整个数据集数据量为131.04GB。该套（男性及女性）人体数据集的三维可视化由香港中文大学王平安教授领导的课题组合作完成。同时，我们利用与清华大学唐泽圣教授领导的课题组联合研制的三维重建软件包进行了器官结构的图像分割和立体重建。

在此，我们将首套中国数字化可视人体图谱奉献给广大读者。全书分为上、下两篇：上篇为男性数据集，2518个断面图像；下篇为女性数据集，3640个断面图像。由于受篇幅所限，不能将6158幅断面图像全部以大图的形式印刷。因此，我们每间隔20个连续断面选1幅断面图像以大图形式印刷，计308幅，每幅图均放置了随图缩放的5cm标尺；用小图形式印刷所有图像，计6158幅。为了使读者清晰地看到本套数据集的其他图像，随书匹配1张含有连续断面图像(.jpg格式)的光盘。前言中插入了CVH的部分CT、MRI和计算机三维重建图像。



马克思说过，“在科学的道路上是没有平坦的大道可走的，只有那些不畏艰险沿着陡峭山路攀登的人们，才有希望到达光辉的顶点。”本书的出版是我们不断求索的漫漫长路中的一个里程碑。在本书即将面世之时，我们无法忘记刚刚过去的奋斗征程，无法忘记进行原始数据采集的日日夜夜……在深入调研和细致分析美国可视化人体（VHP）和韩国可视化人体（VKH）数据集采集方法和数据集图像的基础上，为了使图像更加完整和清晰，我们创建了专用的低温实验室。研究人员需要在−25℃的环境里长时间工作，忍受着寒冷和缺氧带来的痛苦。盛夏时节，重庆气温高达35℃以上，实验室内外温差高达60℃，这对研究人员的身体和意志都是极大的考验。课题组30多位成员绝大部分是博士、硕士研究生或博士后研究人员，为了高质量地完成数

据采集，年轻的学者们放弃了所有的假期和节日，在异常艰苦的环境下24小时不停机、夜以继日地勤奋工作。我们无畏而无悔，坚定而执着！我们愿将本书呈献给我们的师长、同道、学生、朋友和家人。

在本书出版之际，我们诚挚地感谢国家自然科学基金委的评审专家和领导，是他们先后批准了本课题组5项面上项目和1项国家杰出人才基金（No.39925022）的资助，使得本项目的研究工作得以顺利开展；我们由衷地感谢第三军医大学的领导和专家、教授，是他们给予了本项目足额的匹配经费，使得研究工作得以圆满完成；我们特别感谢中国人民解放军总后勤部王谦副部长、第三军医大学吴灿校长、科研部罗长坤部长对本课题组的支持和鼓励。

感谢香港中文大学王平安教授及其领导的课题组全体成员，是他们以坚实的工作基础和高度的工作热情以及真诚合作的精神，及时实现了人体数据集的三维可视化；感谢清华大学唐泽圣教授及其领导的课题组，是他们自 1993 年以来与本课题组的长期友好合作给予了本项目极大的支持和帮助。

感谢美国 Colorado 大学 V.M.Spitzer 教授、傅忠军博士和韩国 Ajou 大学 Min Suk Chung 博士，他们在参加在重庆召开的“首届中、美、韩数字化可视人体国际学术研讨会”期间，亲临实验室参观和座谈，给予本实验室的研究工作充分的肯定和无私的帮助。

永远感谢那些在我们最困难的时候，用各种方式对本项目以及本课题组表示支持、同情和帮助的人们；同时，我们也要感谢那些将遗体捐献给医学科学研究、为人类的健康和幸福做出最后贡献的人们。

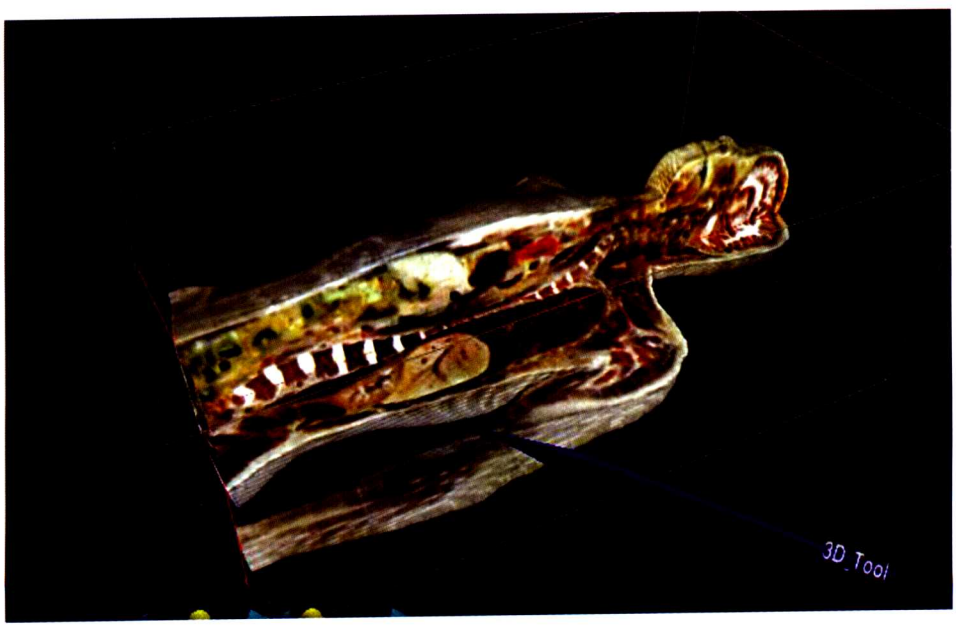
我们真诚地感谢科学出版社的领导和编辑，是他们以战略眼光和国际视野，肯定了本书的科学意义和应用价值，使得本书得以面世。

由于数字化可视人体是一个崭新的研究领域，因作者的水平有限，不足之处在所难免，恳请广大读者不吝赐教。

张绍祥

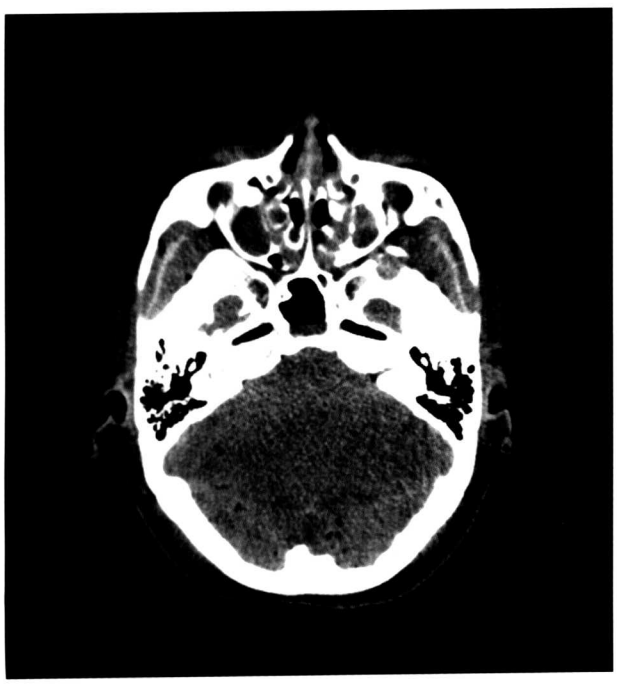
二〇〇三年十月二十三日

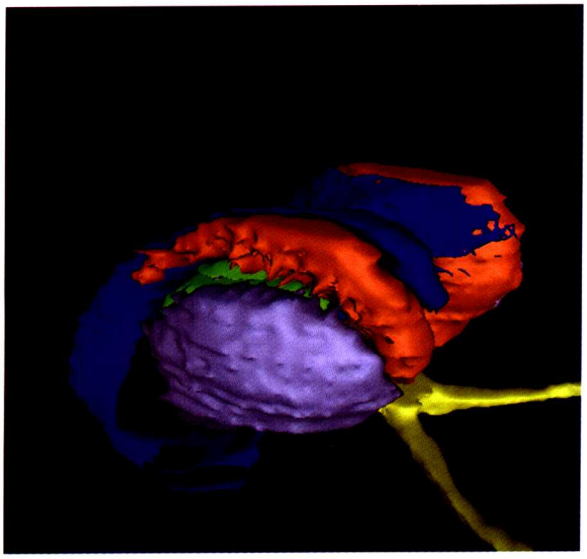
于重庆第三军医大学



Preface

With the coming of the digital era, digital visible human data are in demand in various fields related with human morphology, including medicine, aerospace industry, sports, military affairs, automobile and machine production, and arts . The U.S .National Library of Medicine (NLM) made an early start by initiating "Visible Human Project (VHP)" in 1989. In August 1991,the NLM contracted with the University of Colorado School of Medicine to acquire structural data set of normal human body and achieve 3D reconstruction. The research team led by Prof. V.M.Spitzer adopted the following procedure: First, lab workers used a cryomacrotome to shave off slices of the frozen body. Then, the cross-sections were photographed and scanned into an animation computer to obtain serial images. Next, 3D reconstruction of the human body was achieved. In November 1994, they accomplished the world's first visible human data set and made it available for public use. The data set was derived from a middle-aged male. All 1878 sections spaced at 1.0 mm had been sampled at a resolution of 4,200,000 (2048 $\times$ 2048) pixels. The complete data files occupy 15GB. In December 1995, they accessed the even more detailed data set of the visible female. Altogether, 5189 sections spaced at 0.33 mm had been sampled. The complete data files occupy 43 GB. The U.S. VHP aroused worldwide echoes. Sponsored by NLM in 1996, four sessions of the biennial conference of the Visible Human Project has so far been convened. To date, licenses have been granted to customers in several tens of countries by NLM for use of the data set.

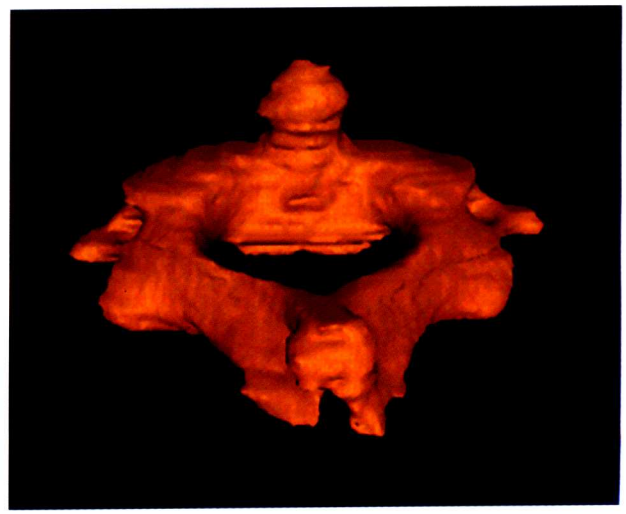


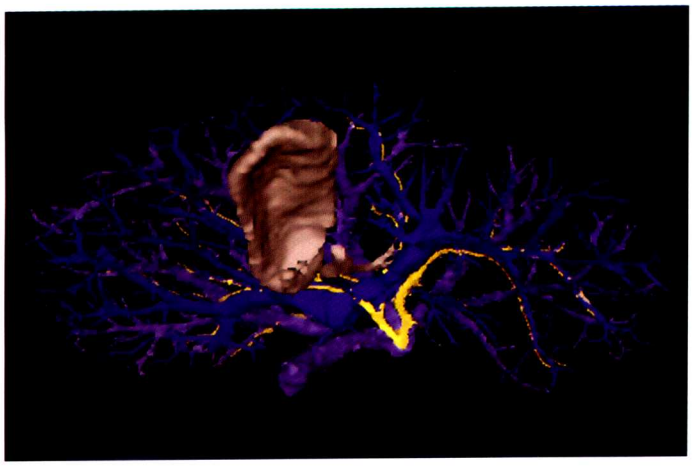


Many research institutions and universities have been or are developing new human computer simulation program and practical products. The University of Washington set up Digital Anatomist Project, Harvard University built Whole Brain Atlas and Surgery Planning System, Stanford University created Virtual Endoscopy System, the University of Hamburg worked on Voxel-Man System, and Rensselaer Polytechnic Institute developed Nuclear Medicine Simulation System. So far, Korea, Japan, Germany, France, Great Britain, and Switzerland initiated their visible human project one after another. Among others, "Visible Korean Human (VKH)" project has already gained remarkable staged progress.With grants from National Science Foundation of Korea, Medical College of Ajou University implemented 5-year VKH project (Mar.2000 – Feb.2005) along with Korea Institute of Science and Technology Information. The first data set was obtained in March 2001 by the research team under direction of Dr. Min Suk Chung. All slices had been sampled at a resolution of 6,100,000 (3040 × 2008) pixels and spaced at 0.2 mm.The subject was a 65-year-old patient who had died of cerebroma. The follow-up research of VKH is going on intensely as planned.

Encouraged by the theoretical importance and vast number of applications of visible human research, many domestic scholars have been paying close attention to the research progress and using the data set made public by the U.S. VHP to perform fruitful research. The 174th and 208th Xiangshan Science Conferences were convened , the themes for both were set as "the scientific project of CVH". The previous work laid basis for research on developing a Chinese Visible Human project.

Our research team at the Third Military Medical University has been involved in the study of human sectional anatomy and computerized 3D reconstruction since 1985. We have been focusing on human thin sectional anatomy since 1990. With grants from National Science Foundation of China for Distinguished Young Scholars, we began our research on acquiring the Chinese Visible Human (CVH) data set in 1999. After almost four years' hard work, we successfully acquired the data set of CVH male and female in October 2002 and February 2003, respectively. Both the CVH male and female were free of organic disease and lesion. The man whose body was used as the CVH male was 35 years old at the time of death. He was 1700mm tall and weighed 65kg. The 2518 slices spaced at 0.5mm for head and neck region (0.1mm at the skull base), 1.0mm for other regions had been sampled at a resolution of 6,300,000 (3072 × 2048) pixels. The data file of each section occupies

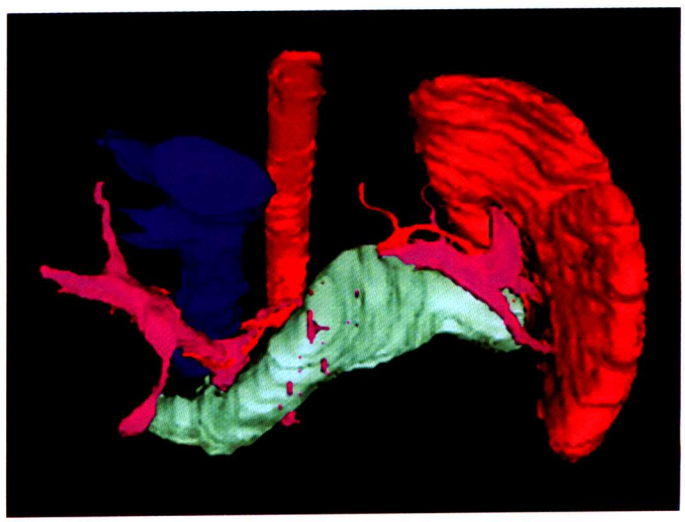




36MB. The complete data files occupy 90.65 GB. As for the CVH Female, the subject was 22 years old at the time of death. She was 1620mm tall and weighed 54kg. The 3640 serial sections had been sampled at 0.25 mm intervals for head and 0.50 mm for other regions. The data file of each section occupies 36 MB (formatted as .tiff). The complete data files occupy 131.04 GB. The 3D visualization of the CVH (male and female) data set was accomplished by the research team led by Prof. Pheng Ann Heng at Chinese University of Hong Kong. Using the software packages for 3D reconstruction developed by our research team and the team led by Prof. Ze-Sheng Tang at Tsinghua University, we also performed image segmentation and stereo reconstruction of the organs or structures of the CVH.

This atlas of CVH is designed for readers with different knowledge backgrounds. The book consists of two sections: the section for CVH male presents you with 2518 images, while the section for CVH female presents 3640 serial cross-sectional images. It's impossible for us to print every image into large-sized pictures because of limited space. Therefore, we selected one image from every 20 serial sections to print into large- sized pictures, totaling 308 images.A 5cm ruler was put in each image. At the same time, all of the 6158 images are printed in small-sized pictures. A CD-ROM disc is attached to the book with the purpose of providing the readers with sharp images of the serial sections. Several CT, MRI and 3D reconstructed images of CVH are inserted in the preface.

As Marx said, "There is no royal road to science, and only those who do not dread the fatiguing climb have a chance of gaining its numinous summits." The publication of the book is a milestone in our endless pursuit of scientific achievements. It reminds us of the ordeals we encountered and the great efforts we've made during data acquisition. Having analyzed the methods of data acquisition and images of VHP and VKH, we built a special low temperature laboratory to guarantee better image integrity and higher clarity. Working for hours in the low temperature laboratory, where the temperature was maintained at −25℃ or below it, the researchers had to endure coldness and hypoxia. They suffered even more physically and mentally when the difference in temperature between in and out of the laboratory reached 60℃ in hot summer days in Chongqing. The majority of our research team are Master's or Doctor's degree candidates and postdoctoral researchers. To acquire high quality data set efficiently, the young scholars worked diligently under arduous conditions day and night, giving up holidays and recreations. We cherish our



memory of overcoming great difficulties to achieve success and will keep doing so.

We dedicate the book to our teachers, colleagues, students, family and soul mates.

We are deeply indebted to the National Science Foundation Committee of China for providing the funds (including one item of National Science Fund of China for Distinguished Young Scholars, No.39925022) for the development of the Chinese Visible Human data set. We are also grateful to the officers and experts at our Third Military Medical University for their financial support, which made our data acquisition accomplished in time.We especially thank Prof. Qian Wang, Prof.Can Wu and Prof.Chang - Kun Luo for their supports.

Prof. Pheng Ann Heng and his research team at Chinese University of Hong Kong deserve special commendation for 3D visualization of the CVH data set. We also gratefully acknowledge the research team led by Prof. Ze-Sheng Tang at Tsinghua University for their long-lasting support and collaboration with our team since 1993.

Prof. V.M.Spitzer, Dr. Zhong-Jun Fu at the University of Colorado, USA, Dr. Min Suk Chung at Ajou University, Korea, visited our laboratory and exchanged ideas with us on CVH when they attended the "International Workshop on Visible Human Research" held in Chongqing. Their encouragement and supports are heartily appreciated.

We thank those who present support, sympathy and aid of any means to our research team and project when we were in hardness. We acknowledge those people who donate their remains to medical research.

We especially acknowledge officers and editors of Science Press for their strategic insight and international vision in approving the scientific significance and application value, which brought this book to fruition.

Visible Human Research is a new field and we are far from knowing everything. For the remaining errors or ambiguities, I' ll take full responsibility. We sincerely welcome feedbacks and comments from the readers.

Shao-Xiang Zhang, Ph.D.

Prof. of Anatomy
College of Medicine
Third Military Medical University
Chongqing, 400038, China
October 23, 2003

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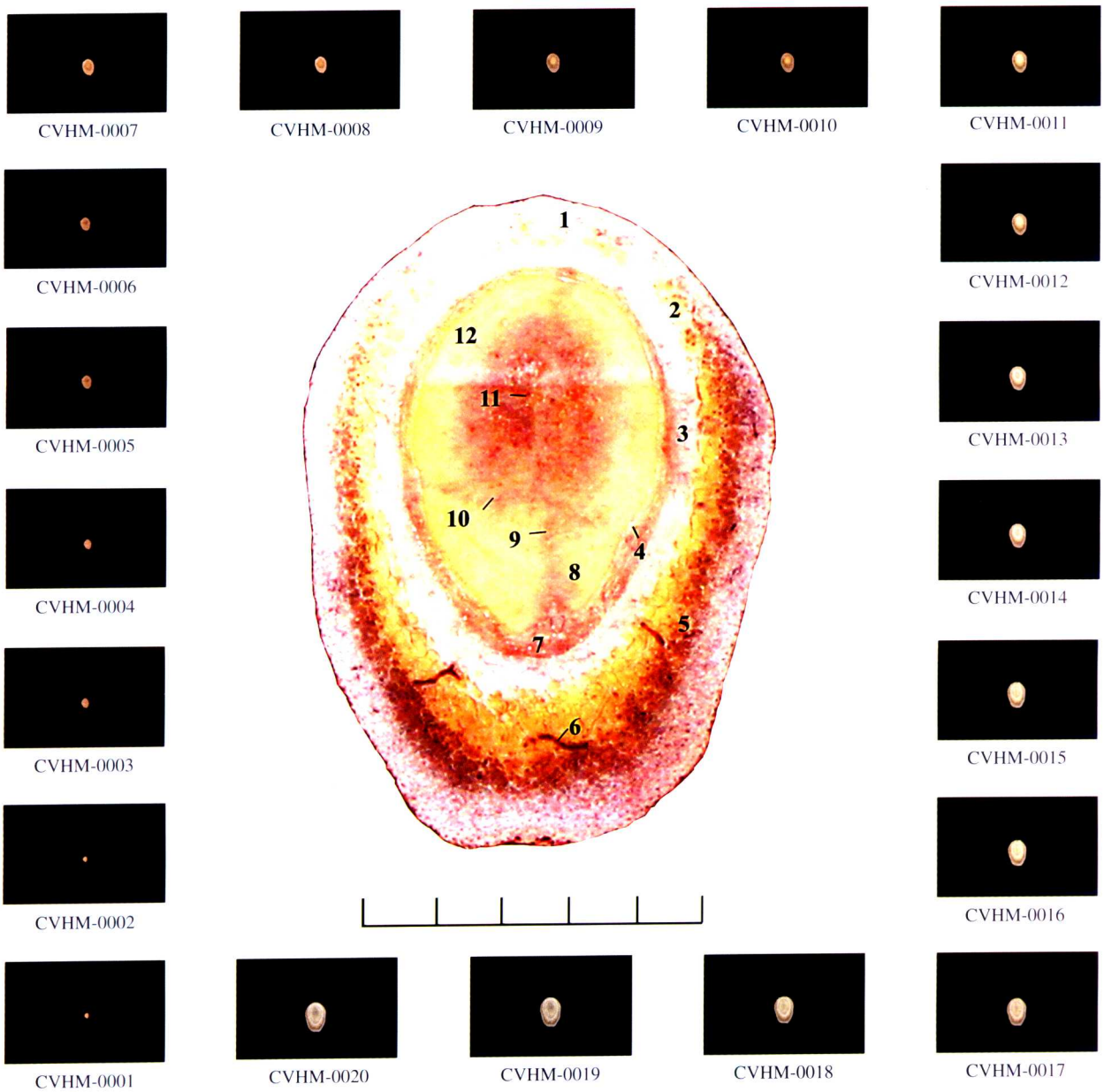

图 1 (Fig.1)

1. 表皮 epidermis 2. 浅筋膜 superficial fascia 3. 帽状腱膜 epicranial aponeurosis 4. 颅骨膜 pericranium 5. 真皮 dermis 6. 头皮血管 scalp vessel 7.腱膜下间隙 subaponeurotic space 8.顶骨 parietal bone 9. 矢状缝 sagittal suture 10. 冠状缝 coronal suture 11. 板障静脉 diploic v. 12. 额骨 frontal bone

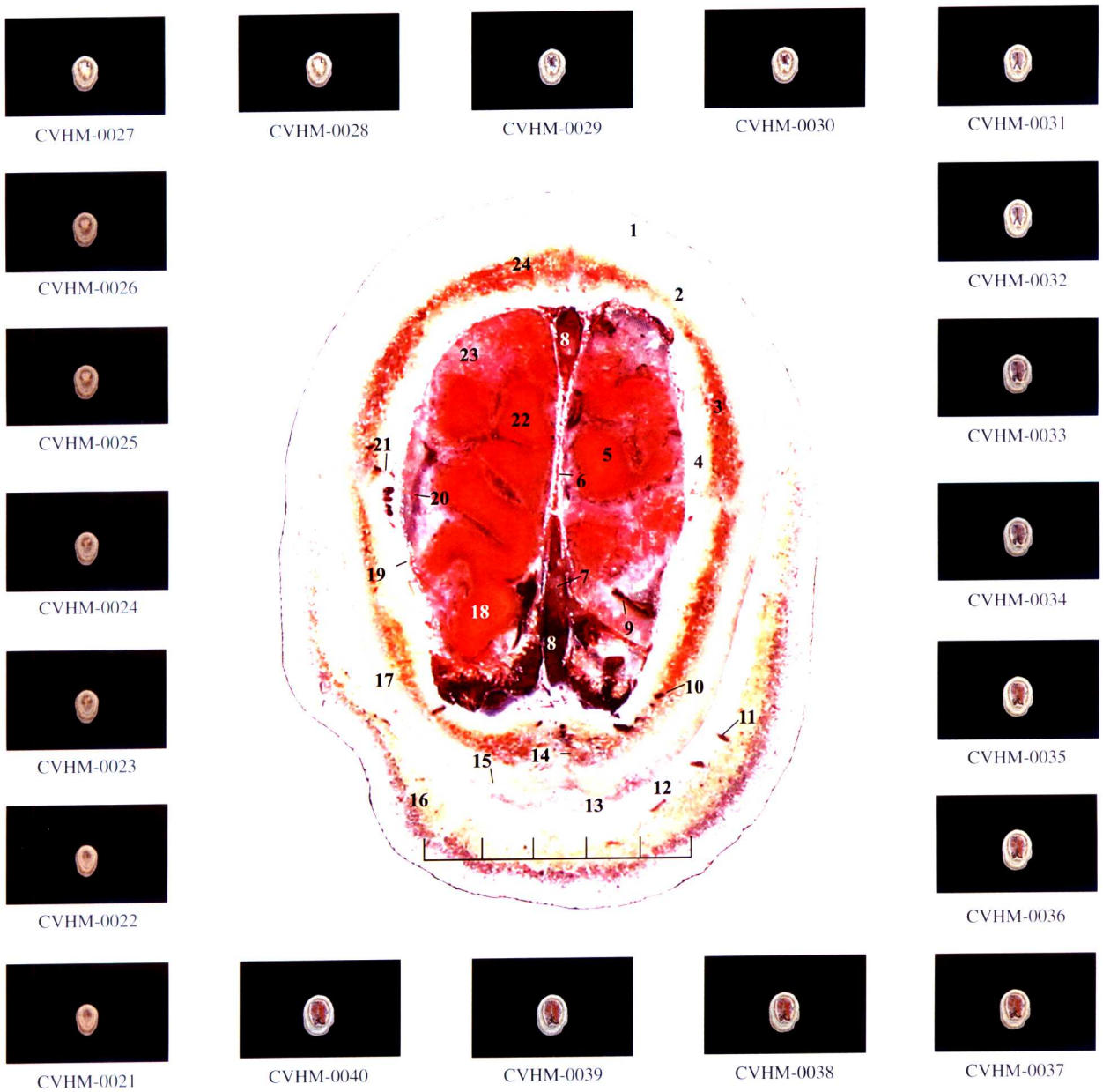

图 2 (Fig.2)

1.皮肤 skin 2.外板 outer plate 3.板障 diploë 4.内板 inner plate 5.额叶 frontal lobe 6.大脑镰 cerebral falx 7.蛛网膜粒 arachnoid granulations 8.上矢状窦 superior sagittal sinus 9.大脑浅静脉 superficial cerebral v. 10.板障静脉 diploic v. 11.头皮血管 scalp vessel 12.帽状腱膜 epicranial aponeurosis 13.腱膜下间隙 subaponeurotic space 14.矢状缝 sagittal suture 15.颅骨膜 pericranium 16.浅筋膜 superficial fascia 17.顶骨 parietal bone 18.大脑皮质 cerebral cortex 19.硬脑膜 cerebral dura mater 20.蛛网膜下隙 subarachnoid space 21.冠状缝 coronal suture 22.额上回 superior frontal gyrus 23.脑蛛网膜 cerebral arachnoid mater 24.额骨 frontal bone