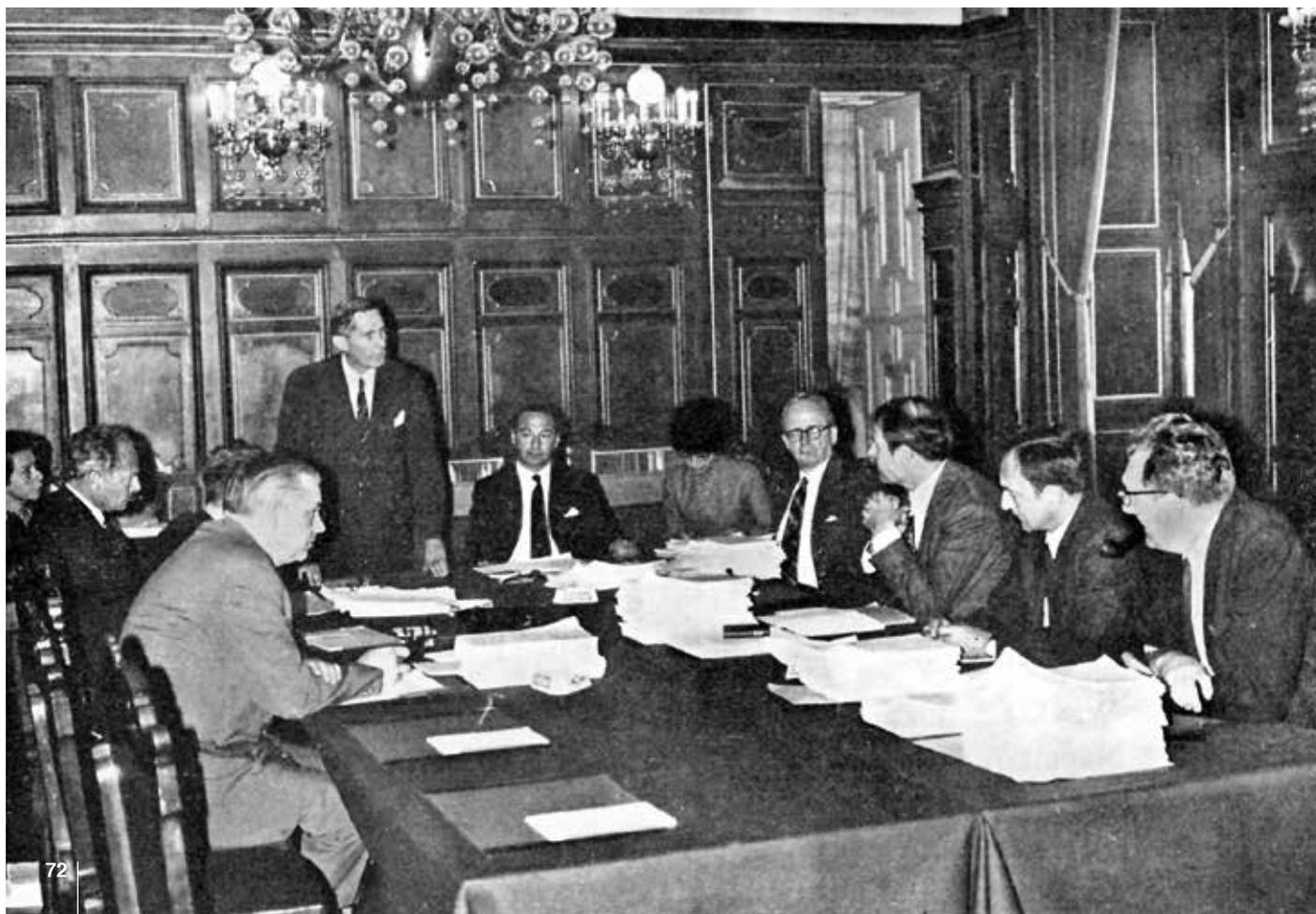


EDUCATION AND TRAINING OF CANCER RESEARCHERS

EDUCATION AND TRAINING OF CANCER RESEARCHERS

Education and training of cancer researchers have been recognized as a paramount need and a key component of IARC's mandate since the very first formulations of its programme in 1965. At that time, training opportunities were available only at a limited number of leading research institutions in economically developed countries. In the field of epidemiology, formal courses and on-the-job training possibilities were even fewer, essentially restricted to the USA and the United Kingdom. IARC's international dimension prompted four main types of initiatives: international training fellowships, Senior Visiting Scientist Awards, international courses, and the development of educational materials. These have become continuing IARC activities aimed at providing the professional knowledge and skills considered necessary for "what comes next" in cancer research.

John Higginson welcomes the members of one of the first IARC Fellowship Selection Committees, in the meeting room made available by the City of Lyon.



INTERNATIONAL TRAINING FELLOWSHIPS

The Fellowship Programme was developed as one of IARC's very first activities. It was initiated in 1966, offering one-year training fellowships to young scientists with no previous postdoctoral experience, and has continued uninterrupted until the present day. Applications are reviewed and evaluated by an ad hoc IARC Fellowship Selection Committee composed of scientists, most of whom are from institutions other than IARC.

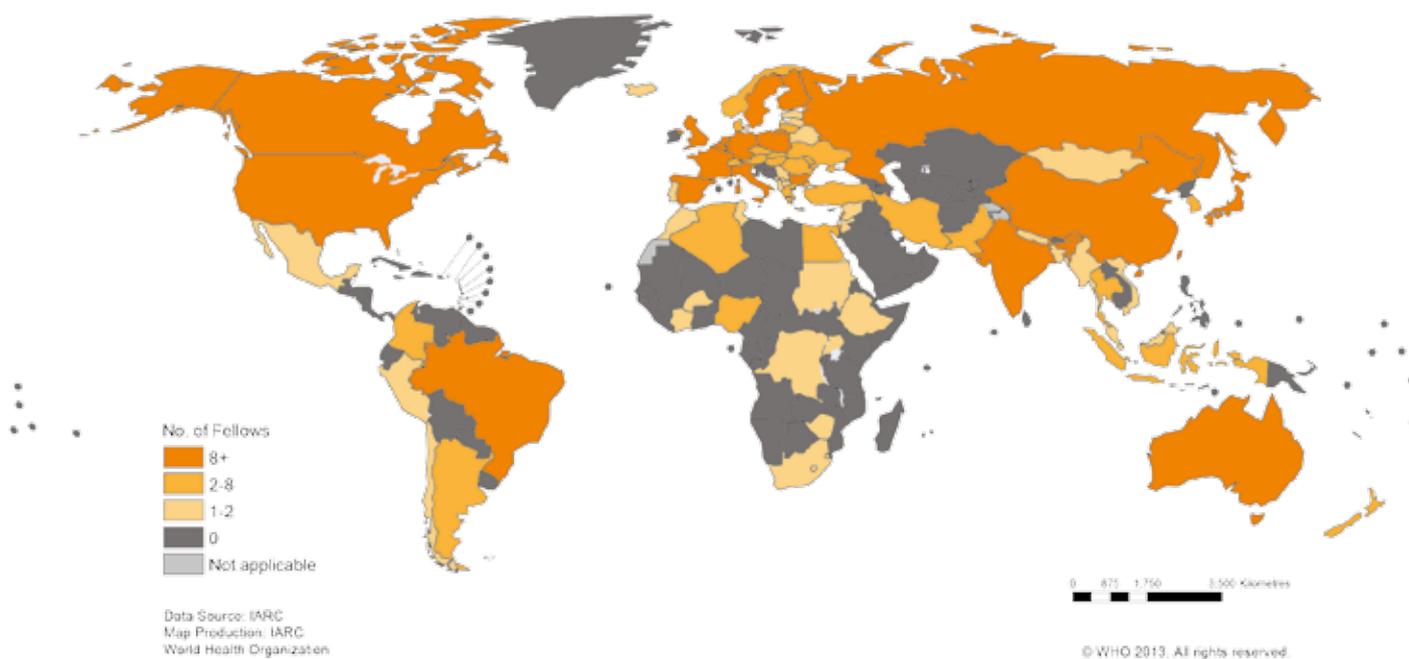
Stipends have kept pace with the cost of living and compare well with those provided by other granting organizations. IARC's core budget funds the programme; additional support has been provided in the past by the Italian Association for Cancer Research and in recent years by the European Union EC-FP7 Marie Curie Actions-People-COFUND programme (IARC Postdoctoral Fellowships) and by Cancer Council Australia (IARC-Australia Fellowships) and the Irish Cancer Society (IARC-Ireland Postdoctoral Fellowships).

Until 2004, fellowship recipients were selected regardless of their country of origin, and the host institution could be anywhere in the world. About 98% of fellows chose institutions in North America and Europe; the USA ranked first (about 50%) and the United Kingdom second (about 20%), followed by France, Sweden, Germany, and Canada. The desire to provide a unique training experience and the increasing public health relevance of cancer in low- and middle-income countries have informed some major changes in the IARC Fellowship Programme in more recent times. First, since 2004, fellowships have been tenable solely within one of IARC's research sections, with an extension for a second year possible, subject to satisfactory performance as evaluated by the Fellowship Selection Committee. Second, selection of fellowship recipients is driven by scientific excellence, but among equally meritorious applicants priority is given to candidates from low- and middle-income countries and to research projects relevant to such countries. This training format means that fellows are integrated into IARC research projects, often resulting in longer-term collaborations that extend well beyond the period of the fellowship.

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Many
of my Italian
students became good
epidemiologists thanks to the
IARC Fellowship Programme,
which allowed them to spend
some years abroad.
– Benedetto Terracini,
long-term IARC
collaborator

”

Over the decades the number of candidates has varied around an average of 50 applicants per year, with peaks of more than 100. A total of 602 fellowships were awarded over the 49-year period 1966–2014, an average of 10–15 per year. In the early years (1966–1976), female fellows were a minority (about 10% of the total); their proportion has increased markedly, reaching 60% in the most recent period (2003–2014). The great majority of fellows (80–85%) return to their home country after the postdoctoral training. Most continue to work in cancer research, and it is significant that the three most recent IARC Directors – Paul Kleihues (1994–2003), Peter Boyle (2004–2008), and Christopher Wild (2009–present) – had been IARC postdoctoral fellows early in their careers – in 1970, 1981, and 1984, respectively – before progressing to prominent positions outside IARC.



Countries of origin of IARC research training fellows (1966–2013). Over the years, the IARC Fellowship Programme has attracted postdoctoral scientists from an increasingly wide range of countries.

The distribution of fellowships by research area has reflected the evolution of disciplines within cancer research. Overall, two thirds of the fellowships have been allocated to the fields of epidemiology and biostatistics (24%), cell biology (18%), chemical carcinogenesis (12%), and viral carcinogenesis (11%), with the proportion for chemical carcinogenesis decreasing over time. The other third of fellowships have been in biochemistry and the growing sectors of genetics, molecular biology, and molecular pathology.

Further training opportunities at IARC arise through the recruitment of postdoctoral scientists, outside the Fellowship Programme, who are supported directly by extrabudgetary funds obtained mostly from

competitive grants awarded to specific IARC projects. The selection of these postdoctoral scientists (currently about 30 per year) is also approved by the IARC Fellowship Selection Committee, to maintain a uniform standard. In 2011, IARC introduced the Postdoctoral Fellowship Charter, an agreement that lays out what is expected of IARC, the supervisor, and the postdoctoral trainee, including participation in training courses in different core research skills such as grant writing, making presentations, bioethics, and biostatistics. In addition, an Early Career Scientists Association has been created by postdoctoral trainees and PhD students, bringing together students, fellows, and other postdoctoral scientists to promote social activities, to facilitate dialogue with IARC management, and to improve opportunities for career development.

“

My greatest achievement is the Fellowship Programme, because it is about bringing knowledge.

– Walter Davis,
former IARC staff member

Postdoctoral fellows don't spend all their time working. These members of the Early Career Scientists Association enjoyed a summer picnic in 2014.



Postdoctoral scientists coming to IARC enter an environment where people of some 50 different nationalities work together towards common goals through research projects conducted across the world. As a result of the collaborative nature of its work, IARC provides opportunities for interactions with scientists from all over the world, and every year IARC welcomes several hundred researchers who attend conferences, workshops, and research meetings. All of these networks offer postdoctoral scientists a remarkable introduction to world cancer leaders and a rich experience that helps equip and inspire them for their future careers. As a postdoctoral fellow from Mexico said recently, upon leaving IARC and returning home as the head of a new research group on molecular mechanisms of carcinogenesis, “It has been a very positive experience. The laboratory facilities are appropriate and up-to-date. The foremost value is the atmosphere at IARC, which favours exchanges between staff, fellows, and external scientists visiting the Agency; fruitful interactions take place easily and pave the way for future collaborations.”

SENIOR VISITING SCIENTIST AWARDS

A prominent feature of IARC's earliest years was the awarding of Travel Fellowships to senior cancer researchers, enabling international scientific exchanges during relatively short visits. In 1983, the Senior Visiting Scientist Award was established, offering scientists with a distinguished record in cancer research the opportunity to spend a longer period of 6–12 months at IARC with the aim of developing a collaborative project. Applications are evaluated by the same selection committee that assesses candidates for postdoctoral fellowships. To date, 44 awards have been made to scientists from 18 countries, more than half of them conducting research in a variety of areas within epidemiology and biostatistics. The presence and contributions of highly qualified external scientists have proven most valuable to strengthen the methodological approaches and widen the thematic perspectives of IARC's research teams. These awards have also been instrumental in reinforcing collaborative links with the visiting scientists' institutions.



Three recipients of the Senior Visiting Scientist Award (left to right): Neil Pearce from New Zealand, currently a professor at the London School of Hygiene & Tropical Medicine, received one of the first awards, in 1982; Jack Siemiatycki, now a professor of epidemiology at the University of Montreal, Canada, was an awardee in 1996; Leticia Fernández Garrote, a professor at the National School of Public Health, Havana, Cuba, was a recipient in 2013.

In a related development, the Expertise Transfer Fellowship was instituted in 2006 to enable established investigators to spend 6–12 months in an appropriate centre in a low- or middle-income country to transfer their knowledge and expertise in areas relevant to the host country and related to IARC's activities. To date, fellowships have been awarded to investigators from France, the Netherlands, Sweden, and the USA to visit Colombia, India, Uganda, and Uruguay to train PhD students in cancer epidemiology, to foster projects on cancer registration, and to investigate the relationships between viruses and cancer.

INTERNATIONAL COURSES

An annex to the very first IARC Annual Report (for 1966) stated: "In the short time since the establishment of IARC, its professionals came to recognize the dearth of competent epidemiologists and biostatisticians in the domain of cancer research. It would therefore be useful if the first of the international courses is devoted to 'Concepts and methods of cancer epidemiology'. It is hoped that the course can be organized in July 1968." The course took place in Lyon on 24 June–5 July 1968, with 30 participants, 23 of whom had all their expenses covered by IARC. Among the invited faculty members were Richard Doll and Donald Reid, who

Participants in the first course on cancer epidemiology in Lyon, in 1968. In the centre of the front row is Louis Pradel, then mayor of Lyon. To his right is Walter Davis, the IARC course organizer. Third from the right in the back row is the course's scientific director, Albert Tuyns, wearing dark glasses. At the extreme left of the photograph is Calum Muir, then head of the Unit of Epidemiology at IARC.





What is interesting to me today, as a senior emeritus professor, is to be invited by heads of cancer research units, for example in Barcelona or Rotterdam, and being told by all those people how important it was in their careers to have attended these short courses by IARC; it was their introduction to epidemiology.

– Norman Breslow, former IARC scientist

was a professor of epidemiology at the London School of Hygiene & Tropical Medicine.

That first course set the tone for what became one of IARC's most popular educational activities. Courses were organized by the IARC education and training professionals, with a faculty that was usually composed primarily of external scientists, joined by some IARC scientists. Participants were selected on the basis of qualifications and involvement in research, with attention paid to the resulting distribution by institutions and countries. Attendance was free. Whenever feasible, total or partial support to meet travel and accommodation expenses was provided by IARC.

These characteristics of IARC courses have remained fundamentally the same over the decades. From those early beginnings with one annual course, the programme developed and stabilized at the level of two to five courses per year, at least one of which took place elsewhere, often in a developing country (see "IARC courses in developing countries"). In the 40 or so years until 2004, 134 courses were organized, 77 of them away from Lyon, in countries spread over the continents. The number of participants has varied from an occasional low of 20 people to a high of about 80, with an average of 30–50 students, most of whom are qualified at postgraduate level. The most frequently covered topics have been epidemiology and biostatistics, with an emphasis on methodology. Other subjects taught have been chemical

John Cairns, an outstanding molecular biologist who made influential contributions to microbiology and cancer biology, took a keen interest in the societal and public health aspects of cancer. The most remarkable aspects of his lectures and conversations were the seeds of reflection that they invariably planted in the listeners.



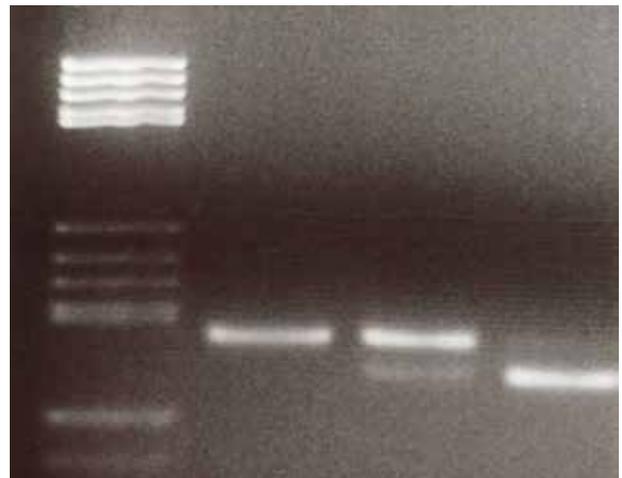
carcinogenesis, virology and cancer, and mutagenesis. A successful series on the detection of environmental health hazards was presented in the 1980s and 1990s at venues in countries including China, Thailand, and Zimbabwe.

In its 50 years of activity, IARC has witnessed, and participated in, the revolution in biology, initially stemming from advances in molecular genetics. In the early 1980s, genes, whose presence could be inferred only indirectly through their influence on physical traits such as eye colour, blood group, or certain heritable diseases, became directly “measurable”. This was a huge change: for the first time, epidemiologists were able to investigate the effects not only of exposure to measurable environmental agents, like tobacco smoke, and of physiological traits, like weight or blood cholesterol, but also of inherited genes. To acquaint epidemiologists with the novel concepts and techniques of molecular biology, IARC organized a two-week course on “Molecular biology for epidemiologists” in Lyon in July 1986. Fifty epidemiologists attended the course, which was led by John Cairns, with a faculty composed of cellular and molecular biologists, geneticists, and virologists. The lectures were complemented by practical demonstrations of molecular biology techniques. The course was offered again two years later, at the Institute for Cancer Research in Oslo, and ushered in subsequent short courses in molecular epidemiology.

In 2005, the first IARC Summer School in Cancer Epidemiology was held in Lyon (see “The IARC Summer School in Cancer Epidemiology”). At the same time, there was a reorientation of the IARC courses; most of them became specialized (particularly in cancer registration and cancer screening), while some were upgraded to an advanced level (e.g. in statistics). From 2008 to 2014, more than 70 courses were held, two thirds of them in low- and middle-income countries, with a total of more than 2500 attendees.

“
I enjoyed very much,
right from the beginning,
being at IARC and meeting
people from all over the world.
– Ann Shannon, former IARC
staff member

A restriction fragment length polymorphism (RFLP) pattern from a 2001 IARC laboratory notebook. RFLP was the first widely used technique to determine variations (polymorphisms) in the DNA sequence between individuals. These variations show up as different bar patterns when a DNA sample is broken into pieces (digested) by enzymes and the resulting fragments are separated according to their lengths.



IARC COURSES IN DEVELOPING COUNTRIES

Walter Davis, who was for many years responsible for education and communication at IARC, recalls the “old days” of the IARC courses.

“In the 1970s, John Higginson was visiting potential countries where IARC could have collaborations. He went to China and told me, ‘You have to go there and tell them how useful epidemiology can be.’ I went and found myself in a room with maybe 50 people where I outlined what cancer epidemiology was about and how a course in epidemiology would be helpful for cancer research in China. They accepted the idea; it had to be approved politically and by the Academy of Science, and it was. So in 1979 we organized a course in Beijing. It was supposed to last four weeks, but it took longer because lectures were slowed down by the translation from English into Mandarin. The Chinese scientists attending the course were very interested in epidemiology and very hardworking. Giving training in China is a very good memory because of the attention and engagement of the students, even though the 1979 course was held in a hotel with no heating; it was so cold that Nubia Muñoz was wearing a fur coat while giving her lectures. In this course, like with other courses, there were one or two teachers from IARC, and all the others came from institutions around the world.



Participants in the IARC course on epidemiological methods held in Beijing in 1979.



Walter Davis was the enthusiastic organizer of a long series of IARC courses around the world. Here, during the 1987 session of the IARC Governing Council, Davis (right) talks to Nikolai Blokhin, who was director of the Institute of Experimental and Clinical Oncology of the Academy of Medical Sciences of the USSR and who served as chair of the IARC Scientific Council in 1970.

“Organizing courses in developing countries was complex. We had to send all the teaching materials, like books, in advance from Lyon. Given the local status of technology, on several occasions we had to send sets of perforated cards and card-sorting needles as tools for the statistical calculations. For a course in Yaoundé, Cameroon, these materials disappeared twice; it was quite stressful. The logistics were complicated because the aim was to recruit students not only from the country where the course was held but from the entire World Health Organization region. In Africa this meant most of the continent. We used to pay for travel and accommodation expenses with traveller’s cheques. I remember once a suitcase with 40 000 dollars’ worth of traveller’s cheques was lost – and eventually found, to our great relief.

“The spirit of IARC was to create a network of international contacts and potential research collaborations between developed and developing countries. In some developing countries, cancer epidemiology was non-existent and we had to plant the seeds through these courses.”

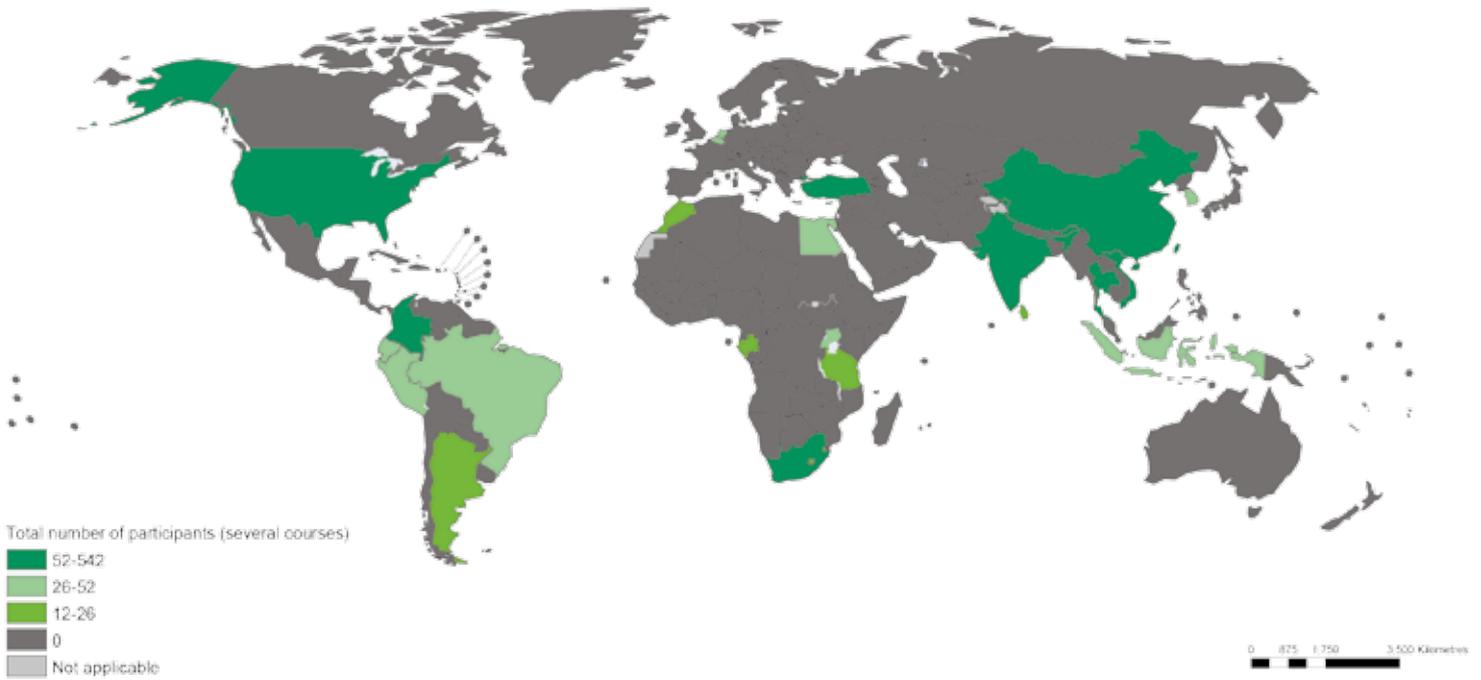
The “IARC spirit” that Davis brought to the courses in developing countries went – and continues to go – beyond the technical aspects, as expressed by a student at one of the most recent courses (a cancer registration course for Russian-speaking participants, held in Kazakhstan in September 2014): “Thank you for the opportunity to be a participant in this course and to acquire skills of working not so much with numbers – but with what they de facto mean, people, as well as their lives, our lives.”

For half a century, the wide geographical distribution of IARC courses has made training available locally in a substantial number of countries, providing valuable technical support for cancer research, particularly in epidemiology. The courses have also promoted the image of IARC as a key organization for international collaborative studies in the cancer field.

As with the postdoctoral training, the “benefit beyond measure” is the number of new collaborations, projects, and long-term friendships that result from sharing a learning environment with other similarly motivated colleagues from as far apart as Chile and China, or South Africa and Sweden. One should not underestimate the encouragement and impetus that springs from such relationships formed during time spent together at a course.

“
*Our science was isolated.
 But IARC broke the isolation
 of cancer research. A lot of young
 Russian scientists became high-ranked
 specialists after working at IARC.
 Because it is international, IARC gives
 equal possibilities to everybody.*
 – Vladimir Anisimov,
 long-term IARC
 collaborator

Locations of IARC international courses (2008–2013). Since the first Summer School was held in Lyon, the IARC courses have been reoriented and are centred particularly in East Asia and Latin America.



Data Source: IARC
 Map Production: IARC
 World Health Organization

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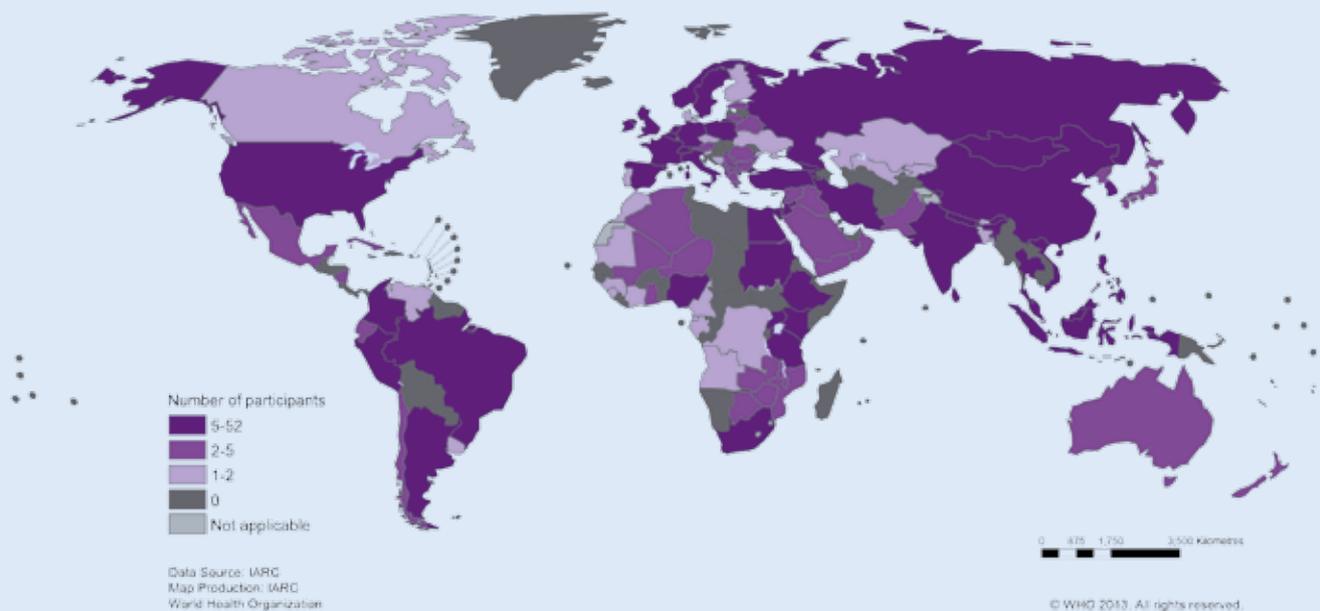
THE IARC SUMMER SCHOOL IN CANCER EPIDEMIOLOGY

The Summer School began in 2005 at the initiative of the then IARC Director, Peter Boyle, with the dual focus of training researchers from developing countries and opening up opportunities for them to become active participants in international collaborative studies. In its first 10 years, the Summer School was organized into two modules: cancer registration (week one) and cancer epidemiology (weeks two and three).



Peter Boyle, here lecturing on epidemiology to Summer School students, was the IARC Director from 2004 to 2008. During his tenure, four countries (Austria, India, Ireland, and the Republic of Korea) became IARC Participating States, strengthening the platform of support and the opportunities for scientific collaborations.

On average the Summer School has accepted 65 students per year, with 40 in the first module and 40 in the second, including about 20 people who complete both modules. More than 600 students have come to Lyon to participate, with a wide geographical distribution. Participants from low- and middle-income countries (more than 90% of all students) are exempted from any course fees. In addition, total or partial coverage of travel and living expenses may be offered depending on availability of funds; over the years, financial support has been provided by the United States National Cancer Institute, the Nordic Cancer Union, the Union for International Cancer Control (UICC), and the Bullukian Foundation.



Countries of origin of IARC Summer School participants (2005–2013). Students come to the Summer School from all over the world.

The Summer School has been very successful, as judged by the students: a survey of participants in the early years showed that more than 90% were able to apply what they learned in their job. Most of the participants considered that the Summer School had been either helpful (73%) or decisive (23%) to their careers, an assessment confirmed by these comments made by participants in recent years.

It was a very educative course and good for me as a clinician as I try to boost the research capacity for our new cancer unit and promote collaboration with other researchers and the local cancer registry. – Leo Masamba, Chief Oncologist, Ministry of Health, Queen Elizabeth Hospital, Malawi (2014)

I will use and share the knowledge on cancer epidemiology and cancer registration to develop a national cancer control and prevention programme. – Badamsuren Tseveen, Head of Research, Education, and Cancer Registration, National Cancer Center, Mongolia (2014)

The first thing I want to do is to share the knowledge with my colleagues at work (Children’s Cancer Hospital Egypt) and my colleagues at the National Cancer Institute (NCI Cairo). I hope that together we will be able to implement two things. The first is to establish a national network for childhood cancers (for cancer registration, biosample storage and collection, standardization of treatment protocols, and clinical research). The second is to establish a similar summer school in Egypt for students of medical sciences and fresh graduates. – Mohamed Sabry Bakry, Head of Biostatistics and Research Informatics Unit, Children’s Cancer Hospital, Cairo, Egypt (2013)

THE “BLUE BOOKS”

Among the materials produced by IARC, the so-called “Blue Books” series (from the colour of the cover), on the histological and molecular classification of tumours, occupies a prominent position. The books are of value for education, research, and clinical pathology practice. Well-defined histological and clinical diagnostic criteria are indispensable for clinical and epidemiological cancer studies, and in 1956–1957 the World Health Organization (WHO) initiated a programme aimed at producing an international classification and grading of tumours that would be accepted and used worldwide. Indeed, classification of tumours was one of the topics considered for the new cancer agency in the early 1960s, before its creation at the World Health Assembly in 1965 (see the chapter “The birth of IARC”). There was also an obvious need for the histological classification of tumours in laboratory animals to be standardized, particularly for use in long-term carcinogenicity experiments (see the chapter “Carcinogens in the human environment”). In 1973, IARC published the first of a series of reference books, *Pathology of Tumours in Laboratory Animals*, coordinated by Vladimir Turusov. Successive volumes dealt with tumours of the rat, mouse, and hamster. Demand was high; the books were reprinted, and a second edition followed in the 1990s.

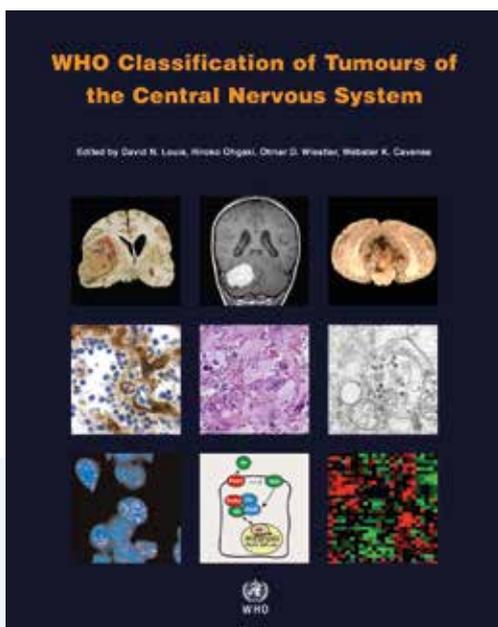


Paul Kleihues (left) at IARC with Jean-François Mattei, then French Minister of Health, Family, and the Disabled. Kleihues was the IARC Director from 1994 to 2003. His tenure coincided with a cancer research environment undergoing revolutionary changes, culminating in the Human Genome Project. He adapted IARC's laboratory activities to this new environment, encouraging connections to IARC's major epidemiology projects. A distinguished neuropathologist, he continued his personal involvement in research on the molecular genetics of brain tumours.

The WHO classification of human tumours began with the first edition (1967–1981), which was essentially based on histological typing. The second edition was led by WHO (1982–2002), until fresh impetus was energetically provided by Paul Kleihues during the 1990s. IARC took responsibility for the third edition (2000–2005), and Kleihues collaborated with Leslie Sobin, editor of the first two editions. It was Kleihues who introduced the transformative information coming from the molecular characterization of human tumours. Each volume of the series is prepared by a group of often more than 100 internationally recognized experts convened by IARC. The “Blue Books” incorporate histology, immunohistochemistry, and genetic tumour profiles as features for diagnostic definition and malignancy grading. They also contain concise sections on epidemiology, clinical signs and symptoms, imaging, prognosis, and predictive factors, making each volume, 250–500 pages long, a compact and comprehensive reference, wonderfully illustrated (see “The WHO Classification of Tumours of the Central Nervous System”).

The complete WHO Classification of Tumours series, of which IARC is now producing the fourth edition, currently includes 11 volumes, covering tumours of the central nervous system; the skin; haematopoietic and lymphoid tissues; endocrine organs; soft tissue and bone; the head and neck; the digestive system; the lung, pleura, thymus, and heart; the breast; female reproductive organs; and the urinary system and male genital organs (see whobluebooks.iarc.fr). Rare is the pathology department anywhere in the world that does not contain one or more volumes of the “Blue Books”. The quantity distributed – about 15 000 copies per year – is a testament to their widely acknowledged value. The books are at the heart of IARC’s broader publishing activities, underpinning other areas of research, including cancer registration (see the chapter “Cancer

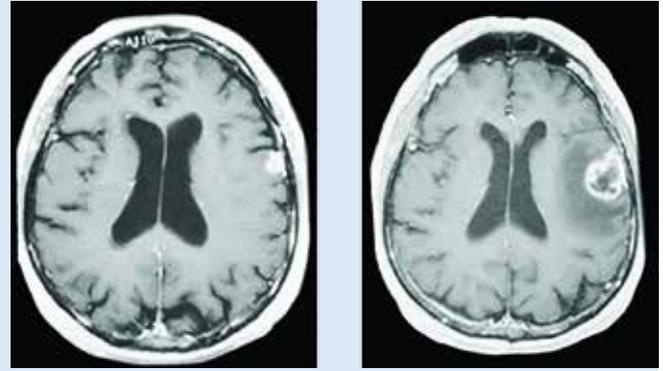
registries: a worldwide endeavour”), biostatistics (see the chapter “Innovation in statistical methods”), and epidemiology (with the comprehensive volume *Molecular Epidemiology: Principles and Practices*, published in 2011 and led at IARC by Paolo Boffetta and Pierre Hainaut, and the preparation of a new edition of the textbook *Cancer Epidemiology: Principles and Methods* by Isabel dos Santos Silva, first published in 1999). The Education and Training Programme website (training.iarc.fr) offers an overview of recorded presentations, reference books, and practical manuals produced by IARC.



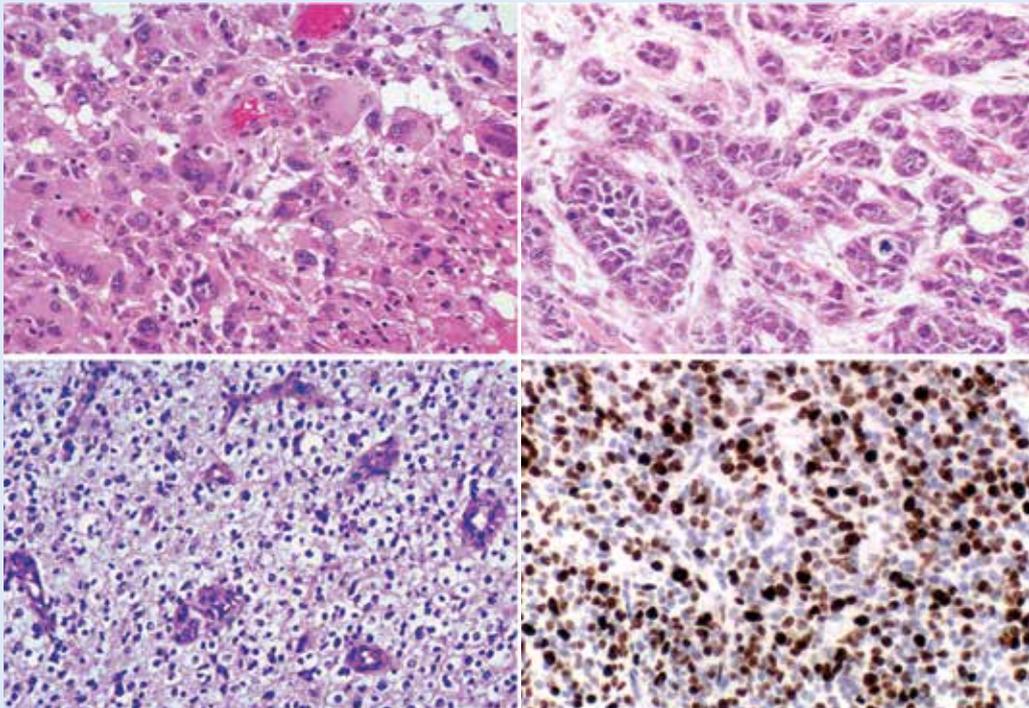
THE WHO CLASSIFICATION OF TUMOURS OF THE CENTRAL NERVOUS SYSTEM

Tumours of the central nervous system were addressed in the first volume of the fourth edition of the “Blue Books”. In this book, as in all others in the series, the text is accompanied by extensive illustrative material. Glioblastoma is the most frequent primary brain tumour. Today its presence can be visualized by magnetic resonance imaging (MRI), but the diagnosis is established by microscopic examination, which reveals characteristic histological features.

Glioblastoma is only one in a list of nearly 130 histological varieties of malignant and benign nervous system tumours within the WHO classification. For brain tumours, as for tumours of any other organ, a detailed characterization of the varieties based on histological and genetic features may help in pinpointing types that have different causes as well as in distinguishing types with different responses to specific treatments. The *International Classification of Diseases for Oncology* (ICD-O) (see the chapter “Cancer registries: a worldwide endeavour”) makes use of the “Blue Books” information and nomenclature to the maximum extent possible.



Rapid evolution of a primary glioblastoma. Magnetic resonance imaging (MRI) shows (left) a small cortical lesion (white spot) that within 68 days developed into a full-blown glioblastoma (right).



These microscopic images of tumour samples show various morphologies of glioblastomas.