THE EVOLUTION OF IBM RESEARCH

LOOKING BACK AT 50 YEARS OF SCIENTIFIC ACHIEVEMENTS AND INNOVATIONS

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By the mid-1950s IBM had established laboratories in New York City and in San Jose, California, with San Jose being the first one apart from headquarters. This provided considerable freedom to the scientists and with its success IBM executives gained the confidence they needed to look beyond the United States for a third lab. The choice wasn't easy, but Switzerland was eventually selected based on the same blend of talent, skills and academia that IBM uses today — most recently for its decision to open new labs in Ireland, Brazil and Australia.

The Computing-Tabulating-Recording Company (C-T-R), the precursor to IBM, was founded on 16 June 1911. It was initially a merger of three manufacturing businesses, which were eventually molded into the $100 billion innovator in technology, science, management and culture known as IBM.

With the success of C-T-R after World War I came increased competition. With growing alarm Thomas Watson Sr., the president of C-T-R, watched his tabulators falling behind competing products. This was particularly vexing because he knew the tabulating business was critical to the company's future, since scales and coffee grinders wouldn't make C-T-R a globally renown company.

Very much like today, T. Watson Sr. saw that big companies were experimenting with tabulating machines to help run railroads, handle accounting at department stores, and keep track of manufacturing and distribution for factories. He realized that collecting, sorting and disseminating information was going to be a big business, requiring investment in research and development.

He began hiring the country's top engineers, led by one of world's most prolific inventors at the time: James Wares Bryce. Bryce was given the task to invent and build the best tabulating, sorting and keypunch machines.

With more strategic moves T. Watson Sr. put the company back on a sustainable growth track and C-T-R was rebranded as International Business Machines (IBM) on 14 February 1924.

A new division is born

By the mid-1940s IBM was really taking off. Between 1940 and 1945 the company grew from 12,000 employees and $45 million in revenue to 18,000 employees and $138 million in revenue. This success gave Watson the confidence to open the first pure science corporate research lab in the USA in February 1945. He did this in New York City, in partnership with Columbia University, as he believed that for a successful research lab direct access to the best talents was paramount (Fig.1).

With his humble initial steps Watson Sr. set the basis for what was to become *IBM Research*, two words which are today synonymous with leading-edge science and innovation.

In 1956 IBM officially created an independent research division incorporating the small labs at Columbia University in NY City with labs in Poughkeepsie (NY) and San Jose (Ca). These labs combined with a small, but ambitious new lab in Europe, were the first steps towards its global R&D map.

Switzerland wasn't IBM's first option for a European research lab. London and Amsterdam were also on the short list, but it was Zurich's openness and dense talent pool which made the city the obvious choice.

How to build a research center

Ambros Speiser, a young Swiss electrical engineer from ETH Zurich, became the first director of IBM Research – Zurich in that summer of 1956. He faced immense challenges ranging from finding a suitable location to attract talented scientists to employ.

As he tells it in the *IEEE Annals of the History of Computing:* "There was no established pattern to follow – an industrial laboratory, separate from production facilities, did not exist in Switzerland."

He eventually rented space in the Pelikan building, a German manufacturer of writing instruments, in Adliswil, 20 minutes outside of Zurich. The location gave employees access to the city by bus, but, more importantly, access to the talents at his *Alma mater* the University of Zurich and the "Polytechnikum" (ETHZ).

While initially focusing on electrical engineering for computer hardware, Speiser wanted the Zurich Lab (ZRL) to have a clear differentiation compared to the US labs. With the support of IBM management he took a new direction towards solid-state physics as the basis for electronic devices of the future. He soon added a mathematics department and quickly the lab outgrew its modest space in Adliswil.

With the approval of then IBM CEO Thomas Watson Jr., son of the founder, Speiser purchased a 10 acre site in Rüschlikon, close to Zurich, to build a new laboratory with its own facilities (Fig. 2a). The official inauguration with several hundred guests took place on 23 May 1963. Several demonstrations were organized on that day (Fig. 3).

The world is our lab

From 1945 up until the 1990s IBM Research was funded primarily by headquarters and by the hardware and software divisions. The scientists had their own research agenda with some occasional technology transfer, but this was not the norm.

This slowly began to change in the 1980s. In this period IBM was already looking at how effective research was and tried to influence the direction in which it had to develop. IBM started joint programs between research and the product divisions with a shared agenda. They created collaborative teams to accelerate the transfer of research results. One notable result from this collaboration was the now iconic red TrackPoint found on millions of ThinkPad keyboards to help users navigate. Some of the great accomplishments at ZRL are summarized in Fig. 4. Two of them provided the Zurich Lab with the highest scientific honor, namely the Nobel Prize in Physics in 1986 for the scanning tunneling microscope (STM) and in 1987 for high-temperature superconductivity. Scanning probe microscopy remains a dedicated area of focus at the lab as IBM scientists continue to look at novel materials and designs for the ultimate switch in the next generations of transistors (Fig. 5)

▲ FIG. 1: (a) The Watson Scientific Computing Laboratory in New York (1940s). (b) Students in class at the Watson Scientific Computing Laboratory

▼ FIG. 2: (a) Aerial view of IBM Research - Zurich in 1963 when the lab first opened in Rüschlikon and (b) today after the construction of the IBM Binnig and Rohrer Nanotech center.

After the tremendous success of the 1980s, not only financially with the invention of the personal computer, but also with outstanding scientific discoveries, IBM found itself entering the next decade in a truly difficult situation.

IBM's near-death experience was caused by its failure to recognize that the 40-year old mainframe computing model was out of touch with the needs of clients. Start-up firms like Sun Microsystems pounced on the opportunity impacting everyone from sales to research.

To preserve their research activities, scientists in Zurich became more proactive in working on actual customer problems — a completely unheard-of concept at the time. The idea was to interact with clients, gain insight into their challenges and find solutions. It turned out to be a great success and in 2000 the Zurich Lab opened up a dedicated facility called the Industry Solutions Lab (ISL), with the goal of hosting and interacting with clients on a daily basis.

The idea was eventually rolled out to other labs and today similar environments exist around the world, with the latest recently opening in Almaden, California, called the Accelerated Discovery Lab.

The strategy to connect IBM scientists with clients to solve the world's grand challenges gave birth to the phrase *"The world is now our lab."*

IBM Research Today

With 3,000 scientists across 12 labs on six continents and a $6 billion R&D budget, IBM Research today is a major driver of innovation for both IBM and its clients.

In October 2013 IBM opened the doors to the first commercial technology research facility in Africa. The new lab based in Nairobi, Kenya, is located at the Catholic University of Eastern Africa. It will conduct applied and far-reaching exploratory research into the grand challenges of the African continent including energy, water, transportation, agriculture, healthcare, financial inclusion and public safety.

The Zurich Lab has also been expanding most recently with the addition of the Binnig and Rohrer Nanotechnology Center (BRNC), named after the two IBM Nobel Laureates (Fig. 2b). This $90 million exploratory research facility includes a state-of-the-art cleanroom combined with six innovative noise-free labs. In such rooms, dedicated to advanced nanotechnology studies, all external perturbations (vibrations, electro-magnetic fields, *etc.*) are reduced to an unprecedented low level, whereas temperature and humidity are stabilized with highest precision.

The BRNC is also used in an open collaboration by researchers from ETH Zurich and the Swiss Federal Laboratories for Materials Science and Technology (EMPA).

Outside of the nano-world IBM scientists are working on some of the important challenges of our society today as part of IBM's vision called Smarter Planet (Fig. 6). The vision is based on the realization that the world's systems and industries are becoming more instrumented, interconnected and intelligent, and that leaders and citizens can take advantage of this state of affairs to improve the way the world works.

▲ FIG. 3: Two IBM scientists (Kenneth Niebuhr and Robert Green) demonstrated for the first time the transmission of voice and other audio information by a light beam generated by an injection laser at the opening of the new IBM Research lab in Rüschlikon (May 22, 1963).

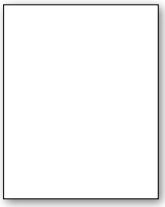
◀ FIG. 4: Some of the major accomplishments at IBM ZRL include the discovery of the STM/AFM, of high-temperature superconductivity, the development of the Token-Ring, the smart card operating system, the Millipede for storage, and liquid chip cooling.

For example, scientists in Zurich are building an affordable photovoltaic system capable of concentrating solar radiation 2,000 times and converting 80 percent of the incoming radiation into useful energy. The system can also provide desalinated water and cool air in sunny, remote locations where both are often in short supply. Another team is collaborating with a consortium of scientists in the Netherlands and South Africa on extremely fast, but low-power exascale computer systems aimed at developing advanced technologies for handling the Big Data that will be produced by the Square Kilometer Array (SKA), the world's largest and most sensitive radio telescope that consortium will build. And scientists across several of IBM's labs are using big data analytics and weather modeling technology to predict output of individual wind turbines and estimate the amount of generated renewable energy. This level of insight will enable utilities to improve the much-strained energy grid.

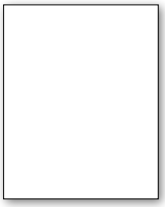
> "With 3,000 scientists across 12 labs on six continents and a $6 billion R&D budget, IBM Research today is a major driver of innovation"

While much has changed at IBM Research – Zurich, the essence of collaboration and the spirit of innovation and excellence that Speiser envisioned remains true to this day.

About the authors



Christophe Rossel received his PhD in physics from the University of Geneva in 1981. After 4 years as research scientist at UCSD, La Jolla (CA) he joined IBM Research - Zurich in 1987. His fields of expertise in condensed matter physics are superconductivity and magnetism, and more recently transport and structural properties of advanced functional materials for CMOS and beyond CMOS technology. Fellow of the EPS and IOP, he was also president of the Swiss Physical Society (2008-12).



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References

[1] IBM Research Laboratory Zurich: The Early Years, Ambros P. Speiser, *IEEE Annals of the History of Computing* **20-1**, 15 (1998) http://dl.acm.org/citation.cfm?id=612719

[2] IBM 100 Icons of Progress: ibm.com/ibm/history/ibm100/us/en/icons/

▾ FIG. 5: Schematic 3D image of a molecular "logic gate" consisting of naphthalocyanine molecules, as probed by a low-temperature STM. By a voltage pulse the two hydrogen atoms (in white at the center of the molecule) change position and electrically switch the entire molecule from "on" to "o ", representing a rudimentary molecular logic-gate. (F. Mohn, L. Gross, N. Moll & G. Meyer, *Nature Nanotechnology* 2012).

▾ FIG. 6: In the span of a century, IBM has evolved from a small busine made scales, time clocks and tabulating machines to a globally integ enterprise with more than 400,000 employees and a strong vision for the f *Smarter Planet* is IBM's latest "big bet" on the future, where Research is stron involved in nding solutions for everyday work and personal lives.