Balzan Prizewinners
Interdisciplinary Forum
Forum interdisciplinaire

2013

Alain Aspect
Quantum Information Processing and Communication

Manuel Castells
Sociology

Pascale Cossart
Infectious Diseases: basic and clinical aspects

André Vauchez
Medieval History

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at the Swiss National Science Foundation, Berne
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- Board

- General Prize Committee

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- Board
Foreword

Alberto Quadrio Curzio, Member of the Board of the International Balzan Foundation “Prize”, Chairman of the Joint Commission (International Balzan Foundation “Prize” - Accademia Nazionale dei Lincei - Swiss Academies of Arts and Sciences) and President of the Class of Moral, Historical and Philological Sciences of the Accademia Nazionale dei Lincei

The Balzan Prizewinners’ Interdisciplinary Forum is the outcome of cooperation between the International Balzan Foundation “Prize”, the Swiss Academies of Arts and Sciences and the Accademia Nazionale dei Lincei. The agreements between the Balzan Foundation and the two national academies, which are articulated through a joint commission, are designed to set in motion and sustain a series of initiatives. There have been three important initiatives to date: an annual lecture, an interdisciplinary forum and an interdisciplinary academic laboratory.

The Annual Balzan Lecture, inaugurated in 2009 and now in its fifth edition, has resulted in a series of academic publications. When the awards ceremony is held in Rome, an Annual Balzan Lecture is held in Switzerland and when the ceremony is held in Berne, an Annual Balzan Lecture is held at the Accademia Nazionale dei Lincei in Rome.

The Balzan Prizewinners’ Interdisciplinary Forum, this year held in Berne, continues the tradition established in 2009 of involving current Prizewinners in an interdisciplinary discussion that is intended to stimulate productive academic debate. An interdisciplinary approach is what in particular distinguishes the Balzan Foundation in its endeavours to disseminate academic learning to a wider audience. The fields of our Prizewinners – as ever – this year range widely, though they also echo each other in interesting ways. They stress the impact on humanity of its immediate surroundings,

\textsuperscript{a} See profile p. 109.
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both natural and artificial, and the effect that man is having on his environment and his future in many differing ways.

In Rome, 2012 marked the inauguration of inteR-La*b, an academic laboratory which is essentially an opportunity for many of the young researchers working on the Balzan Prizewinners’ Research Projects to become involved in interdisciplinary exchanges under the guidance of previous Prizewinners. In 2013 it was held at the University of Lugano.

I am sure that the contributions of this year’s Prizewinners as published here will ensure the spread of the activity of the Balzan Foundation.
Opening Remarks

Daniel Höchli, Director of the Swiss National Science Foundation

Dear Winners of the prestigious Balzan Prize,
Cari rappresentanti della Fondazione Internazionale Premio Balzan,
Mesdames et Messieurs,
Dear Colleagues,

As Director of the Swiss National Science Foundation, it is an honour for me to welcome you to the Balzan Prizewinners’ Interdisciplinary Forum 2013 here in the auditorium of the Swiss National Science Foundation, a classic funding agency that is especially concerned with funding project grants and young researchers, whom we hope will win prestigious academic prizes such as the Balzan Prize later in their careers. So you can see that excellence in research is a common goal of your Foundation and our Foundation.

Therefore, I am very pleased that this event is taking place here on our premises, and I hope that you feel comfortable here in our rooms despite the shabby carpet. However, you should realize that its poor condition has a political motivation: sometimes political bodies meet in this auditorium. Therefore, they can see for themselves that we invest the money they give us in brains and not in carpets.

Ho visto che il programma di questo pomeriggio è molto interessante: sarebbe per me una gioia rimanere tutto il tempo, ma purtroppo ho alcuni altri impegni. Mi auguro tuttavia delle discussioni molto interessanti. Grazie.
Welcome Address

Alberto Quadrio Curzio

I am quite glad and honoured to welcome you all, and to express first of all my thanks to Professor Höchli, President of the Swiss National Science Foundation, who is hosting the Balzan Prizewinners’ Interdisciplinary Forum, and Professor Courvoisier, President of the Swiss Academies of Arts and Sciences, who has organized the Forum. I also thank Markus Zürcher, who always does a fantastic job. I am also pleased to present my regards to the President of the Balzan Foundation “Fund”, Achille Casanova, and to the Deputy President of the Balzan Foundation “Prize”, Enrico Decleva.

I would like to thank Peter Meier-Abt, who will chair the first session, as well as Peter Suter and Luciano Maiani, who will present Pascale Cossart and Alain Aspect. And of course, many thanks also to Professor Gutscher, who will chair the second session, in which we will hear the presentations by Karlheinz Stierle on André Vauchez and Dominique Schnapper on Manuel Castells. I might also add that André Vauchez is a member of the Accademia dei Lincei, and it is thus a pleasure to see that among the four distinguished winners, we have a member of my academy.

Finally, Thierry Courvoisier will chair the interdisciplinary panel, and Salvatore Veca, Chairman of the General Prize Committee, will add some final considerations. So many thanks to all of you.

As everyone here knows, the Interdisciplinary Forum is one of the most prestigious initiatives of the Balzan Foundation, bringing together academics in the sciences and the arts and the humanities to engage in discussion on a common theme, on the occasion of the Awards Ceremony with the Balzan Prizewinners, who are at the top of scientific research.

Details of this you will find in the booklet you have been given, which contains a clear presentation of the Interdisciplinary Forum. It will also be multilingual, as will the Interdisciplinary Panel, where very clear-cut questions will be addressed. All of this in the spirit of the Balzan Foundation which fosters exchange in dialogue among the world’s greatest minds.
Session I

Peter Meier-Abt, Member of the Joint Commission International Balzan Foundation “Prize” - Swiss Academies of Arts and Sciences; President of the Swiss Academy of Medical Sciences

Ladies and Gentlemen, dear Guests,

It is an honour for me to chair the first session of this Forum. I would like to welcome you in the name of the Swiss Academies of Arts and Sciences, which integrate the four academies of Switzerland: The Academy of Natural Sciences (SCNAT), the Academy of Engineering Sciences (SATW), the Academy of the Humanities and Social Sciences (SAHS) and the Academy of Medical Sciences (SAMS). We collaborate at an academic level with the Balzan Foundation.

I would like to congratulate all the Prizewinners, and welcome them here. I will now hand the floor over to my esteemed colleague Peter Suter, who will introduce the first Prizewinner, Pascale Cossart.

Presentation of Pascale Cossart, 2013 Balzan Prize for Infectious Diseases: Basic and clinical aspects

Peter Suter, Member of the Balzan General Prize Committee; former President of the Swiss Academies of Arts and Sciences

It is an honour and great pleasure for me to present the first Prizewinner for Infectious Diseases. Our scientific committee received a long list of possible candidates, and we also sought advice from external experts before making a final decision. Today I have the pleasure to present to you Pascale Cossart, the 2013 Prizewinner for Infectious Diseases. Who indeed is Pascale Cossart? She was born in Lille, and is a French citizen. She holds a Master’s Degree in Chemistry from the University of Lille, and a further Master’s Degree in Biochemistry from Georgetown University. She then came to the Pasteur Institute for her PhD. After some time in Laos as Professor of Biochemistry, she returned to the Pasteur Institute, where she currently holds the position of Professeur de classe exceptionelle and is head of the Unité des Interactions Bactéries-Cellules.

This particular Balzan Prize includes not only a recognition in basic science, but in clinical aspects as well. Pascale Cossart ably covers these two fields, including the
Pascale Cossart is recognized as a pioneer in a discipline that emerged 25 years ago, which combines molecular and cell biology approaches and was termed by her “cellular microbiology”. Her key contributions are the identification of a variety of bacterial virulence factors and strategies, the elucidation of sophisticated mechanisms allowing bacteria to enter, survive and spread in cells and tissues. She has elegantly demonstrated how a bacterium targets and crosses host body barriers. She has also discovered new mechanisms that allow bacteria to down-regulate the innate immune response of the host.

Pascale Cossart’s research has led to *Listeria* becoming both one of the best-studied microorganisms and a model system in infection biology. Her discoveries in relation to this organism have revealed mechanisms shared by many other bacteria and helped solve a number of important problems in cell biology. She and her group were the first to describe how *Listeria* escape destruction by intracellular host defenses, for example, by preventing their capture in vacuoles through the production of a potent pore-forming toxin. She has also shown the presence in the pathogen of an enzyme that neutralizes bile salts, allowing the bacteria to persist in the intestinal tract, and of other proteins which help *Listeria* evade innate immune defenses.

A number of new insights into the pathophysiology of infectious processes have been obtained by Cossart’s group. She has shown that *Listeria* and other bacteria induce rearrangements in the actin cytoskeleton and the cell membrane of the host cell to permit bacterial invasion. These studies have inspired many other investigations into bacterial signaling and intracellular manipulations that facilitate microbial uptake by the host organism.

The new techniques and the creative approaches taken by Pascale Cossart have allowed the multiple ways and mechanisms used by pathogens for efficient infection to be unravelled. Her work has illuminated the methods that pathogens use to exploit and subvert host cell function, and that ultimately will facilitate the development of new therapeutic strategies.

Pascale Cossart is a role model for many scientists, and not only women scientists, for her work both inside and outside the lab, where she has a family to take care of – in both places!

This distinction is in good hands – Pascale Cossart, and *toutes mes félicitations*. 
Thank you very much for this presentation. It is really a huge honour to receive this Prize. I will convey my thanks appropriately tomorrow, but today I want to say that it was a joy to receive the phone call that announced my selection for the award of the 2013 Balzan Prize.

Infectious diseases and in particular bacterial infections are a leading cause of mortality worldwide. They are responsible for 15,000,000 deaths per year – about a quarter of annual deaths worldwide, in particular young children in underdeveloped countries. It is also important to recall that certain cancers are associated with an infectious agent. 15-20% of cancers are caused by either a virus or bacteria. The reappearance of old pathogens, the emergence of new pathogens, the increasing number of antibiotic resistant strains and bioterrorism threats are stressing the urgent need for new antibiotics or new therapeutic strategies. We believe that a prerequisite for the design and generation of novel anti-infectious drugs is a detailed knowledge of infectious processes; it is in this framework that our group is analyzing the infectious process induced by the food-borne human pathogen *Listeria monocytogenes*.

In 1986, we chose to work on this facultative intracellular bacterium primarily because bacterial diseases due to intracellular pathogens were increasingly responsible for important public health problems, and because *L. monocytogenes*, owing to a number of specific properties, appeared as a model system to study intracellular parasitism. It also has the unique property of being able during infection to breach three body-barriers, the intestinal, the placental and blood-brain barriers.

In 2013, this bacterium ranks among the best documented intracellular pathogens. Our group has largely contributed to the characterization of the major virulence factors, to the identification of their cellular ligands, to the discovery of the complex signaling pathways that derive from their interactions, to our knowledge of the cell biology of the bacterial entry process and the cell-to-cell spread, of the resistance of the bacterium to host cell defence strategies and to the relevance of some of these events *in vivo*, in particular in the crossing of two host barriers, the intestinal and the placental barriers.

By studying *Listeria* and listeriosis our group has established several new concepts in different areas of biology, i.e., infection biology, cell biology, and fundamental microbiology.
For the last four years, our five main research themes and objectives have been:

1. **Identification of new bacterial components involved in virulence**
   A. Role of non-coding RNAs in virulence and new RNA-mediated regulatory mechanisms in bacteria
   B. Characterization of new virulence factors

2. **The unexplored facets of the cell biology of infections**
   A. New endocytic and cytoskeletal components involved in bacterial entry into cells and cell-to-cell spread
   B. Post translational modifications during infection
   C. The role of mitochondria and mitochondrial dynamics during infection

3. **The manipulation of host genetic information by bacteria**
   A. Histone modifications upon Listeria infection
   B. Hijacking the heterochromatinisation machinery

4. **Unexplored aspects of the intestinal phase of the infection by Listeria**
   A. Role of commensals
   B. Role of NK cells (collaboration with Eric Vivier, CIML Marseille)

5. **Crossing of host barriers by Listeria** (collaboration with Marc Lecuit, IP)

**Scientific activity**

Our scientific activity during 2008-2013 has essentially led to:

**Objective 1**
1. The description of the transcriptional landscape of Listeria during the switch from saprophytism to virulence
2. The discovery of novel types of RNA-mediated regulation in bacteria
3. The identification of new virulence factors

**Objective 2**
4. The establishment of a new role for clathrin in the reorganization of the actin cytoskeleton during bacterial entry and adhesion
5. The discovery of a lipid phosphatase controlling the entry of Listeria into cells
6. The elucidation of a role of septins in entrapping intracytosolic bacteria targeted to autophagy
7. The first report on a role for SUMOylation in bacterial infection
8. The demonstration of the key role of mitochondrial dynamics during infection and of an atypical mitochondrial fission mechanism

**Objective 3**
9. The discovery that dephosphorylation of Serine10 of histone H3 is mediated by K+ efflux via LLO
10. The identification of the role of SIRT2 in the deacetylation of histone H3 and in infection
11. The characterization of BAHD1 as a new heterochromatinization factor
12. The demonstration that *Listeria* remodels chromatin during infection via an LntA/BAHD1 interaction
13. The discovery that *Listeria* induces the production of interferon type III during infection

**Objective 4**
14. The demonstration of the impact of lactobacilli on oral infection by *Listeria*
15. The identification of an NK cells subset critical for *Listeria* infections (coll E. Vivier)

**Objective 5**
16. The elucidation of a transcytosis phenomenon in goblet cells during infection *in vivo* (coll M. Lecuit)

*Key papers are cited in the paragraphs below and references given at the end.*

**The transcriptional landscape of *L. monocytogenes* during the switch from saprophytism to virulence**

The transcription of the entire *L. monocytogenes* genome was examined by the use of tiling arrays and RNAs from wild type and mutant bacteria grown *in vitro, ex vivo* and *in vivo* (Toledo-Arana et al. 2009). This led to the establishment of the first complete bacterial operon map and the discovery of far more diverse types of RNAs than expected: in addition to 50 small RNAs (smaller than 500 nucleotides), at least two of which are involved in virulence in mice, this study led to the identification of long antisense RNAs covering several open reading frames and long overlapping 5’ and 3’ untranslated regions. It also showed that riboswitches can act as terminators for upstream genes and that when *Listeria* reaches the host intestinal lumen, an extensive
transcriptional reshaping occurs with a SigB-mediated activation of virulence genes. In contrast, in blood, the pleiotropic regulator PrfA controls transcription of virulence genes. Remarkably, several non-coding RNAs absent in the non-pathogenic species *Listeria innocua* exhibit the same expression patterns as the virulence genes. Together these data have unraveled successive and coordinated global transcriptional changes during infection and pointed to previously unknown regulatory mechanisms in bacteria.

We next used RNA-Seq in collaboration with the laboratory of R. Sorek at the Weizmann Institute and identified all the start sites as well as the processing sites which function during transcription (Wurtzel et al. 2012). This study, which was performed after growth of the bacteria in a variety of conditions, showed that the genome encodes for at least 134 non-coding RNAs whose size varies from 50 to 600 nucleotides and 86 antisense RNAs whose sizes vary between 150 and 6500 nucleotides. All our results of RNA-Seq as well as the tiling arrays results together with results of two other groups are available on a public browser: [http://weizmann.ac.il/molgen/Sorek/listeria_browser/](http://weizmann.ac.il/molgen/Sorek/listeria_browser/).

*The discovery of novel types of RNA-mediated regulation in bacteria*

- **Discovery that a riboswitch can generate a regulatory small RNA**
  Riboswitches are classically described as ligand-binding elements located in 5’ untranslated regions of messenger RNAs, which regulate expression of downstream genes. Upon binding of their ligand, they may adopt a secondary structure, which leads to a premature termination of transcription. The fate of the resulting small transcript had remained elusive. A combination of approaches has led to the discovery that an S-adenosyl methionine (SAM) riboswitch in *Listeria* can generate, in the presence of a high concentration of methionine, a small transcript (*SreA*), which can hybridize to the 5’UTR of the PrfA message, and inactivate its translation, establishing a link between nutrient availability and virulence gene expression. Together, these results have uncovered a novel role for riboswitches and a new class of regulatory non-coding RNAs in bacteria (Loh et al. 2009).

- **Discovery of a novel type of antisense-mediated regulation in bacteria: the excludon**
  Analysis of the antisense RNAs encoded in the *Listeria* genome showed that they can be classified in two classes: the short ones and the very long ones. This led to the identification of a new type of regulation by a long RNA, which acts as both an anti-
sense RNA and an mRNA. We called the locus encoding such an RNA an excludon. Excludons generally regulate divergent genes involved in similar or mutually exclusive functions (Sesto et al. 2013).

The excludon paradigm. A general representation of an excludon locus, which consists of divergently oriented genes overlapped by a long antisense RNA (lasRNA), is shown. The overlapping lasRNA can act as a negative regulator for genes encoded on the opposite strand, but it can also be used as an mRNA for the genes encoded on the same strand.

- **Discovery of a riboswitch-regulated non-coding RNA**

Riboswitches are, as mentioned above, located in 5’ untranslated regions of messenger RNAs. In *L. monocytogenes*, a vitamin B12-binding (B12) riboswitch was identified, not upstream of a gene but downstream, and antisense to the adjacent gene, *pocR*, suggesting it might regulate *pocR* in a nonclassical manner. *PocR* in *Salmonella* regulates propanediol catabolism and B12 biosynthesis, and confers an advantage over commensal bacteria which are unable to use propanediol. We demonstrated that the B12 riboswitch is transcribed as part of a non-coding antisense RNA named AspocR. In the presence of B12, the riboswitch induces transcriptional termination, causing AspocR to be transcribed as a short transcript. In contrast, in the absence of B12, AspocR is transcribed as a long antisense RNA, which inhibits *pocR* expression. Regulation by AspocR ensures that *pocR*, and consequently the *pdu* genes, which are under its control and are involved in propanediol catabolism, are maximally expressed only when B12 is present. Together, this study demonstrates how *pocR* and the *pdu* genes can be regulated by B12 in bacteria, and extends the classical definition of riboswitches from elements governing solely the expression of mRNAs to a wider role in controlling the transcription of non-coding RNAs (Mellin et al. 2013).
Expression of pocR is regulated by B12, via AspocR. Model showing proposed regulation of pocR by AspocR (Pd: propanediol).

The identification of new virulence factors

In Listeria, the two main invasion proteins internalin (InlA) and InlB are the founding members of the internalin family, which is characterized by an N-terminal domain made of leucine rich repeats. We have characterized several other internalins that are only present in the pathogenic species L. monocytogenes and absent in the non-pathogenic L. innocua:

- **InlC** (Gouin et al. 2010). InlC, in contrast to internalin (InlA) and InlB which are attached to the bacterial surface, is secreted in the culture supernatant or in the cytosol of infected cells. InlC interacts with IKK-alpha and inhibits the NF-kappa B pathway by slowing down the phosphorylation and consequently the degradation of the I-kappa B protein. InlC is the first reported Listeria protein which interferes specifically with the NF-kappa B pathway and thus downregulates the host response to infection by preventing the production of proinflammatory cytokines and the recruitment of neutrophils at the site of infection.

- **InlH** (Personnic et al. 2010). InlH is a stress-induced surface protein. It does not contribute to bacterial invasion of cultured cells in vitro or of intestinal cells in vivo. Strikingly, the reduced virulence of InlH-deficient L. monocytogenes strains is accompanied by enhanced production of interleukin-6 (IL-6) in infected tissues during the systemic phase of murine listeriosis, but not by enhanced production of any other inflammatory cytokine tested. Since InlH does not modulate IL-6 secretion in macrophages at least in vitro, it may play a role in other immune cells or contribute to a pathway that modulates survival or activation of IL-6-secreting cells. These results strongly suggest that InlH facilitates pathogen survival in tissues by dampening the
inflammatory response. Understanding how it mediates this IL-6 regulation is critical for understanding its role in infection.

- **InlK** (Dortet et al. 2011; Neves et al. 2013). This protein is not expressed in classic broth media but is expressed in infected animals. As first shown by a two hybrid screen, InlK interacts with MVP, an abundant cytoplasmic ribonucleoprotein, so far poorly characterized, but which is known to interact with microRNAs. This interaction takes place when bacteria get out of the internalization vacuole, and protects bacteria from autophagic protein recruitment. InlK is thus, after ActA, the second protein which mediates bacterial protection against autophagy.

**Internalin structures.** The structure of LRR repeats of different proteins of the internalin family as determined by crystallography.

We also characterized several non-internalin virulence factors:

- **OatA** (Aubry et al. 2011). OatA is an O acetyl transferase which modifies the peptidoglycan on the N-acetyl muramic acid residues and, as shown by deleting the gene encoding, this enzyme is critical for virulence. The mutant is more sensitive to lysozyme and to some antimicrobial peptides than the wild type. The analysis of cytokines produced by the mutant revealed that these cytokines are different from those produced by a pgdA mutant, a mutant affecting another peptidoglycan modification and which is also strongly attenuated. OatA is thus a novel virulence factor. These results reinforce the notion that peptidoglycan modifications play a key role in the down-modulation of the immune response.

- **LntA** (Lebreton et al. 2011) is a small secreted and basic protein which is produced at low levels by bacteria *in vitro*. It is present in *L. monocytogenes* but absent
in other Listeria species. LntA targets the nucleus of infected cells, where it interacts with the nuclear protein BAHD1 and inhibits its function, which is to induce heterochromatin formation and gene silencing. Expression of LntA desequesters BAHD1 and triggers expression of interferon stimulated genes (ISGs) during infection. LntA is thus a nucleomodulin which remodels the chromatin during infection, an event critical for infection, as the LntA mutant is attenuated in the murine model.

- **LipA** (Kastner et al. 2011) is a secreted protein with a conserved motif of conventional tyrosine phosphatases. It is present in other Listeria species. We have shown that LipA is secreted by Listeria and displays tyrosine as well as lipid phosphatase activity in vitro acting on PI(3)P, PI(5)P and PI(3,5)P₂. This dual activity as both a phospho-amino acid and phospholipid phosphatase is in line with the high similarity between the predicted LipA structure and that of phosphatase MPtpB, a virulence factor required for intracellular growth of Mycobacterium tuberculosis.

**The establishment of a new role for clathrin in the reorganization of the actin cytoskeleton during bacterial entry and adhesion**

Clathrin is a protein which was classically considered as involved in the internalization of macromolecules or small particles. Our previous results demonstrated its role in bacterial internalization. Phosphorylation of its heavy chain by Src family kinases was shown to be a critical event for both bacterial internalization and adhesion as exemplified by its role in entry of Listeria into cells and in adhesion of enteropathogenic E. coli to mammalian cells. In addition, the proteins Dab2, and Hip1R were shown to mediate the link between clathrin and the actin cytoskeleton, reinforcing the previous hypothesis and definitively establishing that clathrin acts as a hub for the actin cytoskeletal rearrangements necessary for entry and adhesion (Bonazzi et al. 2011b).

Strikingly, the same machinery is involved in the formation of adherens junctions between epithelial cells. These results established definitively that clathrin is not solely involved in endocytosis, but must also be considered as a molecule involved in actin rearrangements (Bonazzi et al. 2012).

**The discovery of a lipid phosphatase controlling entry of Listeria into cells**

L. monocytogenes induces its own entry into a broad range of mammalian cells through interaction of the surface protein InlB with the cellular receptor Met, promoting an actin polymerization/depolymerization process that leads to pathogen engulf-
ment. PI(4,5)P(2) and PI(3,4,5)P(3) are two major phosphoinositides that function as molecular scaffolds, recruiting cellular effectors that regulate actin dynamics during L. monocytogenes infection. Because the phosphatidylinositol 5’-phosphatase OCRL dephosphorylates PI(4,5)P(2) and PI(3,4,5)P(3), we investigated whether this phosphatase modulates cell invasion by L. monocytogenes. Our observations suggested that OCRL promotes actin depolymerization during infection and that through its phosphatase activity, it restricts L. monocytogenes invasion by modulating actin dynamics at internalization sites (Kuhbacher et al. 2012).

Model of InlB mediated entry into non phagocytic cells.

**The elucidation of a role for septins in entrapping intracytosolic bacteria targeted to autophagy**

Septins are cytoskeletal elements less characterized than actin and tubulin or intermediate filaments. They constitute a large family of GTPases which form non-polar filaments. They play different roles at entry into cells. Interestingly, they are recruited by cytosolic bacteria which polymerize actin and surround the bacteria and the actin comet tails. This occurs for *Listeria* and *Shigella*. More surprising is the fact that septins in the case of *Shigella* can entrap bacteria which have started to polymerize actin and thus prevent the motility of bacteria and the cell-to-cell spread. This phenomenon is amplified by TNF-alpha treatment, a multifactorial cytokine which in particular has
important effects on the cytoskeleton. Bacteria entrapped in the septin cages are targeted to autophagy. Entrapment in septin cages and autophagy are interconnected, as inhibition of autophagy prevents septin caging and inhibition of septin prevents autophagy. This study was the first to report a cellular process counteracting actin-based motility (Mostowy et al. 2010).

**The first report on a role for SUMOylation in bacterial infection**

SUMO is a post-translational modification corresponding to the addition of a small ubiquitin-like polypeptide which plays a fundamental role in the cell by controlling transcription, genome integrity, intracellular transport, stress responses and other key biological processes. We showed that *Listeria* induces a global deSUMOylation of host proteins through the degradation of Ubc9, the unique enzyme of the SUMO conjugation pathway (Ribet et al. 2010). This degradation is induced by the secreted factor listeriolysin O. The use of inhibitors has revealed that an aspartyl protease is involved in this process. An hyperSUMOylation of cellular proteins impairs infection, highlighting the key role of some SUMOylated proteins in controlling infection. Current investigation aims at identifying the aspartyl protease(s) involved and the SUMOylated proteins involved in infection.

**Impairment of host cell SUMOylation during *Listeria* infection.** Pore formation by LLO during infection triggers the degradation of the host E2 SUMO enzyme (Ubc9). This leads to a blockade of the SUMOylation machinery and to a global deSUMOylation of host proteins (a). LLO can also trigger the degradation of some SUMOylated proteins (b). This decrease in SUMOylation leads to a modification of host protein activities and is critical for infection.
The demonstration of the key role of mitochondrial dynamics during infection and of an atypical mitochondrial fission mechanism

Mitochondrial dynamics is linked to mitochondrial function in mammalian cells. Video microscopy of mitochondria of *Listeria*-infected cells compared to those in non-infected cells led to the striking observation that bacterial infection leads to a rapid mitochondrial fragmentation, which is specific to *L. monocytogenes* as it is not observed in the case of infection with other invasive enteropathogens. Infection with various *Listeria* mutants allowed us to show that the pore-forming toxin listeriolysin O is the critical factor that induces this fragmentation, and that this protein mediates a calcium influx, which is required for the fission event (Stavru et al. 2011). Fission is transient. It correlates with a transient shut off in mitochondrial respiration and a drop in ATP. However, mitochondria recover their function, demonstrating that the shut-off is reversible. RNAi depletion experiments of either mitofusins – leading to pre-fragmented mitochondria – or Drp1 – leading to hyperfused mitochondria – allowed us to show that mitochondrial dynamics is critical for efficient infection. Our recent results show that mitochondrial fragmentation is atypical, as it is dynamin-like protein 1 (Drp1)-independent, but is dependent on the endoplasmic reticulum as in the canonical Drp1-dependent fission mechanisms induced, for example, by uncouplers (Stavru et al. 2013).

*Listeria* transiently induces fragmentation of mitochondria. HeLa cells were infected or not with *Listeria monocytogenes* (green) and labeled for mitochondria (red) and DNA (blue).

The discovery that dephosphorylation at Serine10 of histone H3 is mediated by K+ efflux via LLO

Following our previous discovery that *L. monocytogenes* dephosphorylates histone H3 through the action of listeriolysin O (LLO), we then showed that an unrelated pore-forming toxin, aerolysin, also provokes H3 dephosphorylation (dePH3). As reported for aerolysin, we showed that LLO also induces a pore-dependent K(+) efflux,
and that this efflux is the signal required for dePH3. In addition, LLO-induced K(+) efflux activates caspase-1. However, we demonstrated that dePH3 is unlinked to this activation. Therefore, our study unveiled K(+) efflux as an important signal leading to two independent events critical for infection, inflammasome activation and histone modification (Hamon and Cossart 2011).

**The identification of the role of SIRT2 in the deacetylation of histone H3 and in infection**

We found that during infection with *L. monocytogenes*, the host deacetylase sirtuin 2 (SIRT2) translocates to the nucleus in a manner dependent on the bacterial factor InlB. SIRT2 associates with the transcription start sites of a subset of genes repressed during infection and deacetylates histone H3 on lysine 18 (H3K18). Infecting cells in which SIRT2 activity was blocked or using SIRT2(-/-) mice resulted in a significant impairment of bacterial infection. Thus, SIRT2-mediated H3K18 deacetylation plays a critical role during infection, which reveals a hitherto undescribed role for SIRT2 and an epigenetic mechanism imposed by a pathogenic bacterium to reprogram its host (Eskandarian et al. 2013).

![Model of Listeria-induced deacetylation histone H3](image)

**Model of Listeria-induced deacetylation histone H3.** *Listeria* induces SIRT2 relocalization from cytoplasm to chromatin where SIRT2 deacetylates H3K18. The consequences of this cascade are the control of host transcription, as illustrated by representative genes regulated by SIRT2, and the control of infection, as assessed by staining cells for the secreted bacterial factor InIC (red), which is overexpressed in the cytosol, and host actin, which is polymerized into comet tails by bacteria (green).
The characterization of BAHD1 as a new heterochromatinization factor

By screening for a protein interacting with LntA, we found a protein which had never been studied. It displayed a BAH domain, a domain known to be present in chromatin associated proteins. By a two-hybrid screen, we identified a series of BAHD1 interactors known to be associated with heterochromatin, e.g., HP1, MBD1 etc. Localisation studies and functional experiments demonstrated that BAHD1 is part of a heterochromatinisation complex which induces gene silencing (Bierne et al. 2009). BAHD1 is a silencer whose identification was permitted through the study of a bacterial factor, reinforcing the view that bacterial pathogens may help to unravel unexpected aspects of cell physiology.

Listeria induced chromatin modifications during infection.

The demonstration that Listeria remodels chromatin during infection via an LntA/BAHD1 interaction

LntA is expressed in vivo but poorly expressed in vitro. In infected tissue cultured cells, constitutively expressed LntA targets the cell nucleus, where it interacts with BAHD1 and inhibits its function, i.e., heterochromatin formation and gene silencing, i.e., LntA de-sequesters BAHD1 and triggers expression of interferon-stimulated genes (ISGs) during infection. Indeed, interferon type III (IFN-lambda) was shown for the first time to be produced in epithelial cells, upon Listeria infection, but ISGs were
produced if and only if LntA was expressed. LntA is thus a nucleomodulin which re-models chromatin during infection, and stimulates ISG expression, an event critical for infection as an LntA mutant is attenuated in the murine model. As a mutant expressing constitutively LntA is also attenuated, our results indicate that the finely tuned expression of LntA in vivo is critical for a successful infection (Lebreton et al. 2011). It will be of the highest interest to understand when and where LntA is produced during infection and how the gene LntA is regulated.

![Model for LntA/BAHD1-mediated regulation of ISGs.](image)

**The discovery that Listeria induces the production of interferon type III during infection**

Having shown that IFN-lambda, an interferon known to be involved in viral infections, is produced during the infection of epithelial cells with *Listeria*, we analyzed this unexpected expression in detail. In intestinal cells, induction of IFN-lambda genes by *L. monocytogenes* requires bacterial entry and increases further during the bacterial intracellular phase of infection. Other Gram-positive bacteria, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Enterococcus faecalis*, also induced IFN-lambda genes when internalized by intestinal cells. In contrast, Gram-negative bacteria *Salmonella enterica* serovar Typhimurium, *Shigella flexneri* and *Chlamydia trachomatis* did not substantially induce IFN-lambda. We also found that IFN-lambda genes were up-regulated in lung epithelial cells infected with *Mycobacterium tuber-*
culosis and in hepatocytes and trophoblastic cells infected with *L. monocytogenes*. In a humanized mouse line permissive to fetoplacental listeriosis, IFN-lambda mRNA levels were enhanced in placentas infected with *L. monocytogenes*. In addition, the feto-placental tissue was responsive to IFN-lambda. Together, these results revealed that IFN-lambda may be an important modulator of the immune response to Gram-positive intracellular bacteria in epithelial tissues (Bierne et al. 2012).

**The demonstration of the impact of lactobacilli on oral infection by Listeria**

A comprehensive analysis of the impact of two *Lactobacillus* species on *L. monocytogenes* and orally acquired listeriosis in a gnotobiotic humanized mouse model was performed. We first assessed the effect of treatment with each *Lactobacillus* on *L. monocytogenes* counts in host tissues, and showed that each decreases *L. monocytogenes* systemic dissemination in orally inoculated mice. A whole genome intestinal transcriptomic analysis revealed that each *Lactobacillus* changes expression of a specific subset of genes during infection, with IFN-stimulated genes (ISGs) being the most affected by both lactobacilli. We also examined microRNA (miR) expression and showed that three miRs (miR-192, miR-200b and miR-215) are repressed during *L. monocytogenes* infection. Treatment with each *Lactobacillus* increased miR-192 expression, whereas only *L. casei* association increased miR-200b and miR-215 expression. Finally, we showed that treatment with each *Lactobacillus* significantly reshaped the *L. monocytogenes* transcriptome and up-regulated transcription of *L. monocytogenes* genes encoding enzymes, allowing utilization of intestinal carbon and nitrogen sources, in particular genes involved in propanediol and ethanolamine catabolism and cobalamin biosynthesis. Altogether, these data reveal that the modulation of *L. monocytogenes* infection by treatment with lactobacilli correlates with a decrease in host gene expression, in particular ISGs, miR regulation, and a dramatic reshaping of *L. monocytogenes* transcriptome (Archambaud et al. 2012).

**The identification of an NK cells subset critical for Listeria infections (coll E. Vivier)**

The complexity of gut cells that participate to mucosal immunity has recently emerged via the identification of several subsets of innate lymphoid cells (ILCs). In the framework of a collaboration with E. Vivier’s group, we have shown that oral *Listeria* infection induces IFN-lambda production in small intestine NKp46 ROR-gamma-t- ILCs (or SI NK cells) and IL-22 production in NKp46+ ROR-gamma-t+ ILCs. However, only IFN-lambda SI NK cells contribute to control bacteria dissemi-
nation. The situation with *Listeria* is thus different from infection with other bacteria, e.g., *Citrobacter rodentium*, in which IL-22 plays a role in the control of infection (Reynders et al. 2011).

*The elucidation of a transcytosis phenomenon in globlet cells during infection (coll M. Lecuit)*

*L. monocytogenes* crosses the intestinal barrier upon interaction between its surface protein InlA and its species-specific host receptor E-cadherin (Ecad). Ecad, the key constituent of adherens junctions, is typically situated below tight junctions and therefore considered inaccessible from the intestinal lumen. The study led by G. Nikitas in M. Lecuit’s lab – cited here because of its important follow up of our previous studies – showed that Ecad is luminal accessible around mucus-expelling goblet cells (GCs), around extruding enterocytes at the tip and lateral sides of villi, and in villus epithelial folds. Upon preferential adherence to accessible Ecad on GCs, *Listeria* is internalized, rapidly transcytosed across the intestinal epithelium, and released in the lamina propria by exocytosis. From there it disseminates systematically. Thus, *Listeria* exploits intrinsic tissue heterogeneity to reach its receptor and has revealed transcytosis as a novel and unanticipated pathway that is hijacked by *Listeria* to breach the intestinal epithelium and cause systemic infection (Nikitas et al. 2011).

**Main references**


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Research programme

Our future research programme is based on our long lasting and deep knowledge of the bacterium *Listeria monocytogenes*, a paradigm for the study of intracellular parasitism and crossing of host barriers by pathogens, as well as an exceptional model in cell biology, and on the unique tools that we have generated, including transgenic and knock-in mice and a *Listeria* transcriptome browser (http://www.weizmann.ac.il/molgen/Sorek/listeria_browser; et al. 2012). We will continue to use *Listeria* as a model organism to explore new landmarks and horizons in microbiology, cell biology and infection biology.

*Listeria monocytogenes* is responsible for severe human foodborne infections. During infection, it disseminates from the intestine to the brain and placenta, after crossing three host barriers, i.e., the intestinal, blood-brain or feto-placental barriers. In most tissues, it is intracellular as it survives in macrophages and invades non-phagocytic cells. *Listeria* then spreads from cell to cell using a process based on actin polymerization at one pole of the bacteria. Several virulence factors and key strategies used by *Listeria* for entry into cells, intracellular life, resistance to innate immune mechanisms and crossing of host barriers during infection have now been characterized in detail. An important step was reached when the genome of this organism and that of the non-pathogenic species *Listeria innocua* were sequenced. *Listeria* has become a multifaceted model, and general concepts in biology have emerged from studies on this organism. Yet, many aspects of the infection have not been examined: many bacterial components and host cell organelles have not been considered, nor have many signaling pathways been addressed. Our analysis should unearth unsuspected concepts in different fields.

We will investigate the infection at several levels: bacterial, cellular, and in many cases, at the tissue and organismal levels, in a spatio-temporal fashion. For several aspects, results obtained with *Listeria* will be challenged in other bacterial systems. Our project themes concern several emerging fields of research and will also pioneer new horizons. Some have been initiated. Others will be launched.

Our project is interdisciplinary in nature as it encompasses the fields of fundamental microbiology (regulation), cell biology, cellular microbiology, innate immunity and epigenetics. It relies on innovative techniques and sophisticated approaches. In all aspects, it is at the forefront of international research, and has four aims:

...
Aim 1: Towards the discovery of novel RNA-mediated regulations
- CRISPRs, Antisense RNAs, riboswitches and small RNAs
- Internal transcription and translational start sites
- Small open reading frames (orfs)
- Secretion of small RNAs

Aim 2: Identification of novel virulence factors and virulence mechanisms

Aim 3: Investigating unexplored facets of the cell biology of infection
- Genome-wide approaches to analyze the successive steps of infection
- Mitochondria and mitochondrial dynamics in infection
- Post-translational modifications in the infected cell:
  SUMOylation, ISG15, Nedd8, Proteolysis, Acetylation

Aim 4: Exploring epigenetic reprogramming during infection
- Histone modifications
- DNA methylation
- Bacterial and host factors involved in chromatin regulation
- Inheritance of epigenetic marks

Together, the diverse and highly complementary facets of this proposal should generate a series of innovative contributions to microbiology, cell biology and infection biology.

Questions and Comments

Peter Meier-Abt

The floor is now open for discussion. May I ask the first question?

This has been a wonderful exposition, and it deals with a subject I have been very interested in: mitochondria. You describe mitochondria fragmentation – when this bacterium runs around within the cell, and then the mitochondria unite again and the cell is ok. How does this function?

Pascale Cossart

People generally don’t know that mitochondria, in fact, are the places, the structures in the cell where there is production of ATP and energy. I was fascinated by mitochondria because they are supposed to be of bacterial origin, and one day I was giving a talk after someone who said mitochondria make filaments. I was not aware of that. And indeed mitochondria do make filaments, which are fusing or fragmenting...
constantly. This is really essential for organism survival, and it correlates with mito-
chondrial function.
Upon infection, the mitochondria, which are filamentous, fragment, and this is
amazingly rapid. Fragmented mitochondria do not make ATP for a short period – the
cell is somehow anesthetized for a while. This is a transient phenomenon, and then the
mitochondria re-fuse again, making ATP. We are studying this phenomenon. What is
interesting is that the phenomenon is atypical. Indeed, we recently published a paper
in PNAS a few months ago reporting this atypical fragmentation, a new phenomenon
involving molecules that we are trying to identify. We have shown that it is the se-
creted bacterial protein which is called Listeriolysin O which is responsible for the
phenomenon of mitochondrial fragmentation.

Peter Meier-Abt

Thank you very much – truly fascinating. I have a brief follow up question. This
is a very complex mechanism, and this bacterium is running around in the cell. But if
we have to develop a treatment which is effective, where would you interfere in this
very complex cell biological mechanism? Before the Listeria goes into the cell?

Pascale Cossart

The problem with Listeria and listeriosis is not really the treatment, because most
Listeria strains are still sensitive to antibiotics. We are lucky that the situation is not
too bad in this respect. One can treat listeriosis with antibiotics, but as Listeria bacte-
ria are intracellular, consequently one has to treat patients for a long period and with
relatively high doses of antibiotics. Generally, we use two antibiotics. The main prob-
lem with Listeria is the diagnosis, which has to be made as soon as possible, because
when the bacteria reach the brain, they may induce neurological sequelae. So what is
really needed is an early diagnosis to prevent these negative consequences. To answer
your question more directly, therapy treatment is not a real problem for Listeria for the
moment. But, as I have indicated, one approach to block the infectious process could
be to block the thermosensor. It would be a totally new biochemical approach.

Peter Suter

Why is the affinity of Listeria to the brain, the liver and some other organs so much
stronger, or are the effects simply more visible there than in the heart and in the lungs?
**Pascale Cossart**

*Listeria* is a bacterium which, once it has crossed the intestinal barrier, is found in the blood; then it is filtered somehow in the liver. The tropism for the placenta, for example, as we have shown, is mainly due to the fact that the trophoblastic cells express E-cadherin, a protein which has a high affinity for the bacterial protein internalin. So, via an interaction between internalin which is expressed on the surface of the bacterium and E-cadherin, the bacteria can adhere and then cross the placental barrier. For the brain, we don’t know for the moment why there is a tropism for this organ.

**Heinz Gutscher**

You are very keen on therapeutics. I have a question about prevention. You showed this beautiful picture of French cheese which is not pasteurized. Now my question is whether there is a technique to avoid *Listeria* from spreading in cheese or are they always there and it is just a question of the dose?

**Pascale Cossart**

Well, what you say is true. *Listeria* is present in many places in the environment and can contaminate many food products. Of course if there are very few bacteria, there is no problem. But if the dose is higher and the chances are higher in a cheese which is not pasteurized, then the chances of getting infected are higher. One has to remember that each individual is not sensible to the same dose of bacteria. The status of the immune system is critical and the elderly are clearly more sensitive than adults.

**Question from the audience**

Are there other pathogens using the same adhesion molecules, i.e., the E-cadherins?

**Pascale Cossart**

There is a report indicating that *Candida albicans* which is not a bacterium – it’s a fungus – can also use E-cadherin. So far, I don’t know any other. E-cadherin is an ideal molecule to bind to! It has a transmembrane domain, and via its cytoplasmic domain it interacts with the cytoskeleton. So – and this is amazing – before we found it as being involved in *Listeria* adherence and entry into cells, I had a discussion with researchers working on E-cadherins, and had said that this protein would be a very good candidate. It happened to be the case, but I think what is particularly
interesting with human E-cadherin is its strong and specific interaction with internalin, while the murine E-cadherin, which is more than 96% similar to the human, does not interact with internalin. We have succeeded to mutate one single amino acid in the murine E-cadherin (a glutamic acid into a proline) and showed that this change led to a strong affinity for the internalin. The co-crystal that I presented to you was not obtained by us, but by a group in Braunschweig, which highlighted that this amino acid was protruding from the surface of E-cadherin and prevented the interaction with internalin, demonstrating how host specificity is achieved at the molecular level.

_Peter Meier-Abt_

Regarding the exit from the cell, is this a passive mechanism, or is it because the cells are dying and the bacteria just leaves?

_Pascale Cossart_

Bacteria don’t really exit from the cell, they spread from one cell to the other. It’s not what is observed with _Legionella or Chlamydia_. For these two bacteria, replication occurs in the first infected cell, bacteria divide, then the cell bursts out. For _Listeria_, bacteria multiply in the cytosol, prevent the cell death and spread from one cell to the other.

_Peter Meier-Abt_

Thank you again for this fascinating account, and congratulations again on winning the Balzan Prize. The next prizewinner will now be introduced by Luciano Maiani, who is also a member of the Balzan General Prize Committee.
I am very pleased to introduce the next Balzan Prizewinner for this year. The prize was assigned to Quantum Information Processing and Communication, and the motivation for the prize to Alain Aspect reads: *For his pioneering experiments which have led to a striking confirmation of Quantum Mechanics as opposed to local hidden-variable theories. His work has opened the way to the experimental control of entangled quantum states, the essential element of Quantum Information Processing.*

There are two parts in this argument. One concerns the past, and one the future. The past is a discussion which started with Einstein and Bohr in the 1930s, about the aspects of reality in quantum mechanics. As many of you may know, Einstein was not satisfied with quantum mechanics, because he thought that it departed from our intuitive vision that in nature there must be elements of reality which we should be able to distinguish. Einstein’s reservations were expressed in a famous article written in 1935 by him, together with Boren Podolski and Nathan Rosen, reporting the so-called EPR paradox.

For a long time, the discussion on EPR was purely on a philosophical level, and most of the community of physicists was not really interested, also in view of the enormous success of quantum mechanics in describing atoms, nuclei and all aspects of microscopic reality. The discussion revolved around a “mumbo-jumbo of philosophical concepts”, to use the definition of a distinguished colleague. However, a few physicists were interested, and among them was an Irish theoretical physicist at CERN, John Bell. In 1964, Bell found that there was a way to ask some questions to experiment with to distinguish between the answer given by quantum mechanics and the answer given by Einstein’s realism. This was in the form of mathematical inequalities, called Bell’s inequalities, and the challenge was to put these inequalities to a real test. There was a long development, and this is where Alain Aspect came into the picture, with the idea to use novel technologies for an experiment on pairs of photons, to measure correlations between them and test Bell’s inequalities. Alain was able to design and conduct the experiment, which was a complete success for quantum mechanics. So much for the past.

The essence of the Aspect experiment was that it gave access, for the first time, to measurements on *single quantum objects*. In the same years, Richard Feynman devised a theory about how one could construct a computer using not the bit that we all know as
a basis – the element that can be in either one of two states, 0 or 1, and that is the basis of the present computer – but the quantum bit, or qubit, a quantum system able to exist in two possible quantum states. Feynman showed that if qubits could be manipulated in an appropriate way, computers which were enormously more powerful than the present classical ones could be obtained. The Aspect experiment essentially gave one physical realization of a qubit and this is why it aroused enormous interest, stimulating all sorts of experimental progress in the manipulation of qubits, whether made by photons (the original experiment) or by other systems, such as cold heavy ions, atoms or others.

At present, there is a whole industry and a whole field of research trying to find a way to assemble and manipulate qubits, and eventually we hope that this will give rise to a new field, which will be called quantum computing. At the moment, quantum computing is still in its infancy, but it will grow for sure.

So Alain Aspect’s experiment was a gate to the future, and this is why it was decided to award the Balzan Prize to him, not only for having solved the discussions of the past, but for opening a new road. The early experiments of Alain Aspect have indeed marked the very beginning of quantum information science. Thank you.

Alain Aspect

Thank you very much for this excellent introduction. For all of us – all the laureates – it is an immense pleasure and immense honor to be here and to receive this prize. Since I understand that the time is limited, I will immediately switch to my subject. Actually, all I have to do is to elaborate on the wonderful resumé of professor Luciano Maiani.

From the Einstein-Bohr Debate to Quantum Information: a New Quantum Revolution?

1. A short history of the quantum revolutions: from concepts to technology and vice-versa

The development of quantum mechanics in the beginning of the 20th century obliged scientists and philosophers to change their worldview [1]. Based on the revolutionary concept of wave-particle duality, it became possible to understand and quantitatively describe the stability of matter, the mechanical and thermal properties of materials, the interaction between radiation and matter, and many other properties of the microscopic world that had been impossible to understand with classical phys-
A few decades later, that conceptual revolution enabled a technological revolution. It is indeed quantum mechanics that allowed physicists and engineers to invent the transistor and the laser – at the root of our information-based society – as well as other wonderful applications such as magnetic resonance imaging, to name only one.

After such an accumulation of successes, one might think that by 1960, all the interesting questions about quantum mechanics had been raised and answered, and that one could focus on applying it. However, with his now-famous paper of 1964 [2], John Bell drew the attention of physicists to a second revolutionary concept, entanglement: quantum mechanics describes a pair of entangled objects as a single global quantum system, impossible to be thought of as two individual objects, even if the two components are far apart. The notion of quantum entanglement had been introduced by Einstein, Podolsky and Rosen in a 1935 paper [3], in order to argue that the formalism of quantum mechanics was incomplete, a conclusion strongly opposed by Bohr [4]. The most remarkable feature of Bell’s work was undoubtedly the possibility to determine experimentally whether or not Einstein was right to conclude that quantum mechanics should be completed by introducing properties (physical reality) attached locally to each particle. The experimental tests of Bell’s inequalities gave an unambiguous answer [5]: the properties of an entangled pair of particles are more than the sum of properties attached to each member of the pair. A few decades after the 1964 paper, the physics of entanglement is flourishing, and thousands of theoretical and experimental papers are found when one types Bell’s inequalities into a search engine.

Starting in the 1970s, another concept has progressively become more and more important in quantum physics: the quantum description of single objects, in contrast to the statistical use of quantum mechanics to describe properties of large ensembles (for instance, the many atoms or molecules of a vapor). That question had also been the subject of debates involving Bohr, Einstein, Schrödinger, and others [6]. The development of experimental methods to isolate, observe and manipulate single microscopic objects [7] such as electrons, ions, atoms and even photons obliged physicists to consider the quantum evolution of single objects, and inspired the development of new theoretical approaches, the so-called Quantum Monte Carlo Wave Function simulations. More recently, progress in nanofabrication and in experimental methods have allowed physicists to create artificial quantum objects that push the border of the quantum world to larger and larger systems that still need to be described as single quantum objects.

It is not an exaggeration to say that the realization of the importance of entanglement and the clarification of the quantum description of single objects have been at the root of a second conceptual quantum revolution. It may well be that this once purely
intellectual pursuit will also lead to *a new technological revolution*. Indeed, physicists have endeavored to use the control of individual quantum objects and apply entanglement to conceptually new ways of transmitting and processing information. These are the new fields of *quantum cryptography*, *quantum teleportation*, *quantum computation* and *quantum simulation*. If it keeps its promises, quantum information may have a dramatic impact on our societies, but we do not yet know the end of the story.

2. The first quantum revolution

Five years after the introduction by M. Planck of the quantization of energy exchanges between light and matter [8], A. Einstein took a major step further in 1905, by proposing the quantization of light itself to understand the photoelectric effect [9]. R. A. Millikan found experimental evidence in favor of Einstein’s hypothesis [10]. Convincing evidence of the existence of atoms – doubted until the beginning of the twentieth century – was provided by various observations and arguments, including Einstein’s explanation of Brownian motion [11]. Together with many other experiments, these observations convinced physicists and philosophers to accept the granularity of matter and energy in the microscopic world. Moreover, N. Bohr’s 1913 model of the atom gave for the first time a quantitative description of the stability of atoms and of the way they emit or absorb light [12].

It took another decade to establish a comprehensive paradigm of quantum mechanics, centered around the 1925 formalisms of Heisenberg on the one hand, and Schrödinger on the other. The latter was a wave equation for matter, completing a beautiful duality: like light, matter can behave as either a particle or a wave, elaborating on the original idea of L. de Broglie [13]. The former, however, relied on the mathematics of matrices. The two formalisms were shown to be equivalent by Dirac. The success of this formalism was incredible. It became possible to understand chemical bonds, the electrical and thermal properties of matter, to describe particle physics, to understand exotic properties of matter such as superconductivity (the absence of electric resistance in some conductors at low temperature), or superfluidity (the absence of viscosity of liquid Helium at low temperatures). Studies in light-matter interaction were refined by orders of magnitudes, fitting perfectly within the quantum mechanical framework, which had been refined to be applied both in the elementary phenomenon (quantum electrodynamics) as well as in complex situations encountered in condensed matter. But in the early 1950s, quantum mechanics still appeared as a game to be played by physicists purely for the sake of progress in knowledge, without any impact on everyday life.
The electronics and information age: quantum mechanics applied

Even if the public is not always aware, the applications of quantum physics are all around us in electronics and photonics. The transistor was invented in 1948 by solid-state physicists, after fundamental reflections about the quantum nature of electrical conduction [14]. This invention and its descendents, micro-fabricated integrated circuits [15], clearly had a monumental impact. Like the steam engine over a century earlier, the transistor changed our lives and gave birth to a new era, the information age.

The second technological progeny of quantum mechanics is the laser, developed in the late 1950s [16]. Some of its applications are obvious in every day life: bar code readers, CD recorders and players, medical tools, etc. Less visible but perhaps more important is the use of laser light in telecommunications, where it dramatically boosts the flow of information: terabits (millions of millions of information units) per second can be transmitted across the oceans through a single optical fiber.

Basic research on atom-photon interactions has continued to develop, leading to applications. For example, in 1997 a Nobel Prize was given to S. Chu, C. Cohen-Tannoudji and W. D. Phillips for the development of methods for the cooling and trapping of atoms with lasers. Cold atoms are now used in a new generation of gravimeters based on atom interferometry, which allow us to explore the underground. Another spectacular application is cold atomic clocks, whose accuracy is now better than $10^{-17}$ (one second accuracy in three billion years – almost the age of the universe!) Better clocks will improve the accuracy of the global positioning system (GPS), as well as fast information transfer. Coming full circle, these improved clocks and gravimeters can be applied to fundamental questions, such as tests of general relativity, or the search for slow variation of fundamental physical constants. The first quantum revolution, with its interplay between basic questions and applications, is still at work.

3. From Einstein’s questions to Bell’s inequalities tests: entanglement comes of age - The Bohr-Einstein debate

Quantum mechanics was constructed at the price of several radical – and sometimes painful – revisions of classical concepts. For instance, to take into account particle-wave duality, quantum mechanics had to renounce the idea of a classical trajectory, as stated by the celebrated Heisenberg inequalities. One can also illustrate this renunciation of classical trajectories by remarking that in an interference experiment the particle “follows many paths at once.”
Such renunciations were so radical that several – including Einstein and de Broglie – could not admit their inevitability, and so differed from Bohr, who had carved the Rosetta Stone of interpretation of the new theory under the name “the Copenhagen interpretation”. Einstein did not challenge the formalism and its provisions directly, but seemed to think that the renunciations put forward by Bohr could only signify the incompleteness of quantum formalism. This position led to Homeric debates when Einstein tried to find an inconsistency in Heisenberg inequalities, and Bohr always came up with a convincing rebuttal.

But in 1935, Einstein raised a completely different objection. Rather than considering the behavior of a single quantum particle, for which the Heisenberg relations state that the position and the velocity cannot be both perfectly defined, Einstein considered two quantum particles, and he discovered that the quantum formalism allowed this pair to be in a totally new kind of quantum state, named an entangled state by Schrödinger. In such a state, both the velocities of the two particles and their positions are strictly correlated. Therefore, by making a measurement of the position of one of the two particles, one can know with certainty the position of the other one. But we could instead have measured the velocity of the first particle and then infer the value of the velocity of the second. Since we could have waited until the last moment to choose between measuring the position or the velocity of the first particle, this choice could not have affected the second particle, because no influence can propagate faster than light according to Einstein’s relativity. Both the position and the velocity of the second particle were thus perfectly well determined before the measurement, Einstein argued, a possibility not envisaged by the standard formalism of Quantum Mechanics, which is thus incomplete. The reasoning was published in March 1935, in a paper authored by Einstein, Podolsky, and Rosen [3]. Bohr was reportedly shattered by the EPR paper, and it took him no more than four months to get his reply published [4]. He concluded that the EPR reasoning was not sufficient to conclude that quantum mechanics is incomplete. I have read Bohr’s paper many times, and I must admit that the detailed reasoning is not the clearest. But isn’t it Bohr himself who declared that “truth and clarity are complementary”, i.e., that by trying to be too clear, one may lose the depth of the scientific reasoning? In contrast to Bohr, Schrödinger reacted positively to the EPR paper, and coined the term “entanglement” to characterize the lack of factorability of an EPR state [17]. Actually, it seems that most of the physicists did not care much, since at that time it appeared that adopting one or the other point of view was only a matter of interpretation of quantum formalism. Indeed, Einstein and Bohr did not disagree on the results of the calculation, but on the conclusion to draw about the need or the possibility to complete that formalism.
It took another 30 years until John Stuart Bell totally changed the situation, when he discovered that taking Einstein’s point of view seriously leads to inequalities in contradiction with the predictions of quantum mechanics. The debate had thus shifted from the domain of epistemology to the domain of physics, since it could be settled by questioning nature or by doing an experiment. Three pioneering experiments were carried out in the early 1970s. Two of them, by Clauser and Freedman, and by Fry, vindicated quantum mechanics against Bell’s inequalities [18]. But these experiments were still different from the ideal scheme on which the theoretical debate was based, and it took us almost a decade to take advantage of the dramatic progress in optics (in particular in lasers), and come up with a series of experiments closer and closer to the core of the debate. These experiments were eventually carried out in 1981-1982 [19, 20]. The last experiment addressed for the first time the crux of Einstein’s reasoning, since it was possible to rapidly switch the settings of the measuring apparatuses at the last moment, in order to prevent any possibility of communication at a velocity respecting the velocity of light speed limit. The result was clear: Bell’s inequalities were still violated. Bohr was right: a pair of entangled particles, even widely separated in a relativistic sense, remained one global object that could not be considered as made of distinct components with individual properties. Further experiments have all confirmed a clear violation of Bell’s inequalities, in schemes more and more ideal.

4. The second quantum revolution in action: quantum information

After the experimental observation of the violation of Bell’s inequalities, it could be thought that it was the end of the story. But in fact some physicists, in particular Feynman [21], realizing that entanglement is definitely different from wave particle duality, proposed using it for new applications, and laid the groundwork for a new field of research, quantum information. Quantum information involves totally new ways of transmitting and processing information, such as quantum cryptography, quantum teleportation, quantum computing and quantum simulation. If these new a new, more precise and refined series of tests like these was performed in the 1990s [5], and a new generation of experiments is underway. M. Giustina, A. Mech, S. Ramelow, B. Wittmann, J. Kofler, J. Beyer, A. Lita, B. Calkins, T. Gerrits, S. Nam, R. Ursin, and A. Zeilinger, “Bell violation using entangled photons without the fair-sampling assumption,” Nature 497 (7448), 227-230 (2013); B. G. Christensen, K. T. McCusker, J. B. Altepeter, B. Calkins, T. Gerrits, A. E. Lita, A. Miller, L. K. Shalm, Y. Zhang, S. W. Nam, N. Brunner, C. C. W. Lim, N. Gisin, and P. G. Kwiat, “Detection-Loop-hole-Free Test of Quantum Nonlocality, and Applications,” Physical Review Letters 111 (13) (2013).
methods become practical and available on a large scale, they may well change our society as deeply as the inventions of the transistor, the integrated circuit and the laser, i.e., the fruits of the first quantum revolution, our society into the Information and Communication society.

**Quantum cryptography** [22]

Cryptography is the science of encoding and/or transmitting a secret message without its being read/understood by a third party. Both encoding and code-breaking have progressed due to advances in mathematics and to the ever-increasing power of computers. When contemplating the continuing progress of encrypting and code-breaking over the ages, it seems clear that the security of an encrypted transmission can be assured only on the hypothesis that the adversary (who is trying to break the code) has neither more advanced mathematics nor more powerful computers than the sender and intended receiver.

By contrast, in quantum cryptography, the security of a transmission rests on the fundamental physical laws at work in quantum mechanics. There, it is possible to detect an eavesdropper by using the trace that is necessarily left by him/her [23, 24], since in quantum physics all measurements perturb the system in some way. In quantum cryptography one can check the absence of such a trace, and then be certain that the message has passed without having been read by a spy.

In the method invented by A. Ekert [23], the extraordinary features of entanglement are used in a fascinating way. Two partners, Alice and Bob, can obtain two identical copies of encoding keys (to be used later), i.e., random series of 0 and 1, without the possibility that a spy intercepts the key, since the key does not exist before Alice and Bob effect their measurements. If a spy manages to make the key appear and take a copy of it, his/her presence will be revealed by the observation that Bell’s inequalities are not violated, in contrast with the situation where there is no spy.

Many demonstrations of quantum cryptography have been carried out, and commercial systems are already available and experimented in commercial (banking) or government (elections) activities.

**Quantum computing** [25, 26]

In the early 1980s, the fundamental assumption in information theory—that all computers are conceptually equivalent— started to be challenged. Several scientists, for instance R. Landauer or D. Deutsch, suggested that if one had a quantum
computer, one could implement radically new algorithms to perform certain tasks. A breakthrough happened in 1994 when P. Shor [27] showed that a quantum computer should allow one to factor large numbers in times much shorter than with conventional methods. Factorization belongs to a class of problems (complexity class) whose solution (with classical computers) requires a time super-polynomial in the size of the problem (that is, the time needed grows faster than any power of the number of digits in the number to be factored). With a quantum computer running Shor’s algorithm, on the other hand, the computation time would only grow as a power of the size of the number. This discovery had considerable conceptual implications, since it showed that, contrary to what had been thought previously, the complexity class of a problem was not independent of the type of machine used. It was also the starting point of an immense experimental effort worldwide aiming at realizing a quantum computer capable of implementing quantum algorithms like Shor’s.

Several groups have started to develop the basic elements of a quantum computer: quantum bits and quantum gates. A quantum logic gate performs basic operations on quantum bits – or “qubits” – just as an electronic logic gate manipulates ordinary bits. However, in contrast to normal bits, which can take only one of the two values 0 and 1, quantum bits can be put in a superposition of 0 and 1. A quantum logic gate must thus be capable of combining two quantum bits to produce an entangled state, which is the superposition of the four possible combinations (0,0), (0,1), (1,0), (1,1), of the basic two-qubit states. It is the possibility to work with such entangled states that opens new, incommensurate possibilities as compared to the classical algorithms. To give a flavor of it, let us notice that if one entangles ten qubits, the number of combinations of 0 and 1 states is now $2^{10} = 1024$, while for 20 entangled qubits it is $2^{20} =$ about 1 million. This means that with a limited number of qubits, constituting a quantum register, one can in principle store a huge amount of information, and that any operation acting on an entangled state can process a huge quantity of information, realizing a kind of massively parallel computing.

Experimental research on quantum gates is extremely active, and has already obtained important results. Many approaches are being explored, with a diversity of physical realizations of qubits, including atoms, ions, photons, nuclear spins, Josephson junctions and RF circuits [28].

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It may make an enormous difference: see for instance the example in ref. 25, where the factorisation time of a 400 digit number can be reduced from the universe age to a few years.
For all these systems, there are large unknowns. A universal quantum computer would rely on the ability to entangle hundreds of thousands of quantum bits, and perform thousands of operations before decoherence disrupts the quantum register. Decoherence results from the interaction with the outside world, and its effect is to wash out entanglement, putting previously entangled objects into a state where they behave as separated objects. The scalability to a large number of entangled qubits may turn out to be overwhelmingly difficult, since it is generally observed that decoherence dramatically increases when the number of the entangled particles increases. An entire community of experimentalists and theorists are engaged in that quest. Understanding and reducing the effects of decoherence may well be the key question facing quantum computation as a technological revolution. But even in the absence of an efficient quantum computer, the idea of quantum computation is certainly a milestone in computation science.

**Quantum simulation**

In contrast to quantum computing with quantum gates and qubits, another kind of quantum computing is already operational, that is, quantum simulation. Quantum simulation is in fact what was primarily suggested in Feynman’s paper [21] of 1982, often considered as the starting point of quantum information. In this paper, Feynman shows first that it is absolutely impossible to store a quantum state of many entangled quantum systems in a classical computer, since this would demand a number of bits larger than the number of atoms in the universe. He then concludes that the only support for such a huge quantity of information is a quantum system involving many entangled elementary quantum systems. A quantum computer made of many entangled quantum bits would be such a system. But there is another possibility, which has already led to several experimental implementations, including in my own laboratory. It consists of considering a situation difficult to investigate directly, for instance, many entangled electrons in a material, and simulating it with a system similar but offering more possibilities of study, such as many ultra-cold atoms in a potential synthetized with laser beams [29].

A first example is the case of electrons in a perfect crystal, i.e., in a perfect periodic potential. We can simulate such a situation by placing many ultra-cold atoms (atoms with motion perfectly controlled at the quantum level) in a potential constituted of laser standing waves whose intensity is modulated in an absolutely perfect periodic way along the three dimensions of space. This realizes a perfect lattice of potential wells where the atoms may be trapped. The cold atoms system has two main advantages.
Firstly, one has many observation tools allowing experimentalists to directly observe the atoms and record their distribution in space, or the distribution of their velocities. Secondly, one can change parameters such as the height of the barrier between neighbor trapping sites in contrast to the case of electrons in a piece of material, where the parameters are given by the very nature of the material and can hardly be modified. By lowering the barriers between the sites where atoms were trapped, experimentalists could observe a transition from a situation where the atoms are fixed to a situation where they can propagate freely [30]. This would correspond to a transition from an insulating to a supra-conducting state in the case of electrons, and such a quantum transition, called a Mott transition, had been predicted decades ago, but never observed directly until it was studied with ultra-cold atoms.

Another example, which has been studied in several laboratories including mine [31, 32, 33], is a completely different situation. The atoms are plunged in a disordered potential realized with laser beams, where the intensity varies randomly in space, achieving a disordered potential that we can describe accurately with the tools of statistical optics. This has allowed us to observe another emblematic phenomenon of condensed matter physics, Anderson localization [34, 35]. This fully quantum phenomenon was predicted more than fifty years ago. The prediction was that when the randomness of the potential is large enough (or equivalently the density of impurities in a material is large enough), the motion of the particles (the electrons in a material) would not only be hindered, but even totally stopped due to a quantum interference between the many multiple-scattering paths. This is again a quantum phase transition, which has never been observed directly with electrons in materials, but has been directly observed and studied with ultra-cold atoms [35].

To describe such condensed matter situations, only idealized theoretical models exist, and it often happens that we have no exact solutions with these models. Quantum simulators allow one to implement these models, explore their solutions by changing the parameters, and check whether some of these solutions correspond to the observed phenomena.

5. Conclusion: towards a second technological quantum revolution?

The second quantum revolution was first a conceptual revolution, based on the recognition of the revolutionary character of entanglement and on the manipulation and control of individual quantum objects, allowing experimentalists to entangle them. Quantum information has emerged as a consequence of this conceptual revolution, and one may wonder if it will change our society as deeply as the first quantum
revolution did, bringing us into the information and communication society. We do not yet know the answer, but we can contemplate what has already been accomplished and what is left as an open question.

Quantum cryptography is already out of research laboratories, and one can even buy quantum cryptography systems from startup companies. This is not an insignificant application, when one considers the growing concern about privacy of communications. The fact that the security is absolute, at least as long as the laws of quantum physics remain valid, means dramatic progress. Indeed, one should remember that if somebody records a message encoded with a standard cryptography method today, it is very likely that a decade from now, it will be possible to decipher the message, owing to the continuous increase in the power of classical computers, and this may be very harmful. In contrast, a message encoded with quantum cryptography methods will remain secret forever, as far as quantum mechanical basic laws are not found to be false. This is why there are many efforts at the moment to develop quantum cryptography, on the one hand by extending the range of its implementation, which is not yet at the scale of continental or of intercontinental communications, and on the other hand by making its implementation more and more user friendly, and not reserved to sophisticated users such as governments or banks.

In contrast, it is fair to say that at the moment nobody knows whether it will be possible to build a general purpose quantum computer made of many quantum gates allowing one to entangle tens of thousands of quantum bits. At the moment, the world record is of fourteen entangled qubits realized with ions, and it is very unlikely that such technologies can be scaled up by a factor of more than one thousand, if no fundamental breakthrough happens. One should not underestimate, however, the fact that one has several examples of artificial quantum bits that have been realized with nanotechnologies, for instance, Josephson junctions or RF circuits operating in the quantum regime. With such artifacts, one has the perspective to scale up the number of entangled qubits, just like the technologies of microelectronics has made it possible to implant thousands, then millions and billions of transistors on a single wafer to realize the extraordinary modern microprocessors. But for the time being no such system exists, and this is why the alternative of quantum simulators is so attractive in order to attack important problems of condensed matter involving many entangled particles. Interesting results have already been obtained and constitute remarkable proofs of principle. There is reasonable hope that such simulators will allow us to understand hopefully intriguing material such as high critical temperature superconductors, or more modestly amorphous silicon, essential for cheap photovoltaic cells.
From a conceptual point of view, it should be emphasized that trying to entangle more and more elementary quantum objects may have far reaching consequences. Nobody knows whether fighting the harmful effects of decoherence is just a matter of improving the technology, or if one will find an absolute scale beyond which it becomes impossible to entangle quantum particles. If this happened, it would not only mean that we have to renounce a quantum computer in the form that we are contemplating at the moment, but it would also be an extraordinary fundamental discovery, since it would mean that the frontier between the quantum world and the classical world has been identified. This question is still totally open, although it was raised almost one century ago, at the very beginning of quantum mechanics, when Bohr argued that in order to read the results of experiments on quantum objects, we need classical measuring apparatus. But he never told us where to put the frontier between quantum and classical objects.

Whatever the outcome of that quest, we will understand the quantum world much better. And on the other hand, I have no doubt that even if we don’t have a quantum computer, we will have a host of quantum technologies stemming from the second quantum revolution.

Finally, I would like to express my thanks to two first class engineers who were instrumental for the success of the 1982 experiments, Gérard Roger and André Villing. There were also the already mentioned two (then) young master students, Philippe Grangier and Jean Dalibard, who joined me in the years 1981-1982 to complete the experiments for which I have received the Balzan Award. They have ‘grown up’ since that time, and are now famous quantum physicists. It was a privilege to have them with me at an early stage of their career.

Reference notes


Questions and Comments

*Peter Meier-Abt*

Thank you very much for this brilliant talk. So, I’m not a physicist, but let me ask one question. I worked in Basel, and you probably know the people there… quantum physics and quantum computing is very popular, and they always said, that a quantum computer is possible. When talking to physicists in Zurich, they were very sceptical, and said they have been talking about that for a long time, and that quantum computers will probably never exist. Now, what is your opinion?

*Alain Aspect*

To have a general quantum computer, that is to say, a computer on which you can implement a general kind of algorithm, it would demand at least a hundred thousands entangled qubits. But I have explained that when you want to entangle more and more qubits, decoherence is more and more harmful. The world record at the moment, which is held by Reiner Blatt in Innsbruck, is 14 (one four) entangled ions. So there’s a long way to go. My personal belief is that, either we find something new, for instance, some sub-space of the Hilbert Space that is well-protected from decoherence, or we will not have a quantum computer in its most general form.

This quest is, however, fascinating for the following reason. I explained that if we have a really large number of entangled qubits, it’s like Schrödinger’s cat, and this addresses an important question about the frontier between the quantum and the classical world. Nobody knows where this frontier is. Now there is a possibility that by trying to entangle more and more qubits, people will discover a fundamental reason why we cannot pass a certain scale. This would answer the question of the frontier between quantum and classical worlds. It is still an extraordinarily important question, and in my opinion, this is one of the good reasons to try to build a quantum computer.

On the other hand, there is a simpler version of a quantum computer, which is a quantum simulator, as proposed by Feynman in his paper in 1982. Such simulators, I’m pretty sure, will give results that we could not calculate by normal techniques.

So the answer about the possibility of a quantum computer is ‘maybe yes, maybe no’. Make your choice.

*Peter Meier-Abt*

Thank you very much. A question from Professor Quadrio Curzio?
Alberto Quadrio Curzio

I am an economist, and I really admired your presentation on the one hand, but am worried by it on the other, because these days the speed of computers is already too fast for dealing with economic systems. In fact, the speed and the power of ICT and computers has split the world economy into at least three “sectors”: the real economy, which deals with goods, commodities and services connected to them; the financial and banking economy, which is strictly connected with the real sector by financing it; the high speed financial sector, which grows continuously in increasingly sophisticated trading systems. While the first two sectors move at a relatively similar speed, the third one moves much faster.

My question is: what is going to happen when this kind of quantum information is applied to economic systems? Are we going to have an “econo-quantum”, which has a speed so high that no one will be able to control it? In the past we had political economics, then mathematical economics and then physics-economics. In the future will we have quantum economics?

I think that these revolutionary events might have enormous consequences on the markets, because the speed of transactions increases more and more, and even now it is already practically impossible to control the speed of the computer in buying and selling financial assets. The split between the world yearly GDP and the total amount of yearly financial transactions is continuously increasing, and so it is more and more difficult for institutions to regulate markets.

I understand that my question is a little bit outside the field, but I think it is a fundamental one for economists.

Alain Aspect

You are right. Physicists have always considered this kind of question. For instance, progress in relativity and quantum mechanics gave the atomic bomb. This is another example where physics can have bad consequences. I think there is only one answer: it’s regulation. I mean, there are treaties against nuclear bombs being developed everywhere. It belongs to governments to make such regulations.

Where does physics come in the solution? In providing tools. Physicists have provided the tools to check that the treaties on nuclear arms are respected. Similarly, if governments make rules against fast trading, we can provide accurate methods to check that people do not violate the rules about the timing. But we physicists, or you economists, cannot implement the rules. Economists can explain to governments why
they should make rules, and we can provide the tools to implement the rules. So we should work hand in hand.

*Peter Meier-Abt*

Thank you very much. We have time for one last question.

*Milan Ilic, journalist*

You mentioned your colleague Anton Zeilinger. He lives in Vienna, and I know him personally. He has recently been elected President of the Austrian Academy of Sciences, and my question regards him: have we already been witnesses to the beginning of the third revolution in the field of cryptography? Because as far as I know, several years ago, Zeilinger proved that he could send crypted messages – *Verschränkungen* – under the Danube for several kilometres.

*Alain Aspect*

Anton Zeilinger is part of a big European consortium, which was strongly supported by the European Union, a program that has demonstrated practical quantum cryptography. It has been very successful. As an outcome of it, there have been several start-up companies. There is one in France, and in many other countries as well. A very advanced one is in Switzerland. It is called ID Quantique and was put forward by former students and collaborators of Nicolas Gisin. And ID Quantique is so successful – if we can speak of success – that Swiss banks are using quantum cryptography for preserving the banking secret (you can comment on that if you want…). But it was also used in Switzerland to communicate the results of the votes from one office to another, just to show that it can really work in the real world. And so there’s absolutely no doubt that quantum cryptography will be used.

Last week I met the European commissioner on new technologies, Nellie Kroes. She was extremely excited about quantum. And I’m pretty sure that quantum cryptography will be used, maybe not on iPhones, but at least when you really want to be sure of secrecy. You should realize one point: if nowadays people register messages encoded with the RSA method, so that they cannot decipher the messages today, they will be able to decipher the messages ten year from now, with the increase in computers’ power. And it may be harmful.

In contrast, if you use quantum cryptography, in principle, it’s forever, unless we
discover that quantum mechanics has a flaw. But as far as quantum mechanics works, quantum cryptography is secure.

Thus, I am not sure regarding quantum computing, but I am pretty sure regarding quantum cryptography. Also regarding quantum simulators, I’m pretty sure we’re going to have results.

Peter Meier-Abt

Thank you all very much.
Session II

*Heinz Gutscher, Member of the Joint Commission International Balzan Foundation “Prize” - Swiss Academies of Arts and Sciences; President of the Swiss Academy of Humanities and Social Sciences*

As President of the Swiss Academy of Humanities and Social Sciences, I have the honour to moderate this session. Let’s start by giving the floor to the General Prize Committee member Madame Dominique Schnapper who will present Prizewinner Manuel Castells.

**Présentation de Manuel Castells, lauréat Balzan 2013 pour la sociologie**

*Dominique Schnapper, membre du Comité général des Prix Balzan ; directrice d’études à l’École des hautes études en sciences sociales (EHESS), Paris, membre honoraire du Conseil Constitutionnel*

En hommage au génie politique suisse, j’introduis la langue française dans cette séance. Le Comité général des Prix Balzan a choisi Manuel Castells pour lui remettre le prix pour la sociologie. Le Comité a été impressionné d’abord par la triple culture de Manuel Castells qui est à la fois un savant catalan, un peu français – il a été plusieurs années à l’École des hautes études à Paris avec mon collègue et ami Alain Touraine –, puis c’est un homme de la Californie et enfin du Royaume-Uni. Ce n’est pas seulement qu’il voyage, il a intégré les cultures sociologiques, et je dirais les cultures tout court, de ces nations. Pour le Prix Balzan, prix international, il répondait à l’une de ses ambitions.

Le Comité général des Prix Balzan a également été impressionné par la quantité de ses travaux, mais aussi par leur ampleur et leur ambition.

collectives qui défient les structures du pouvoir et deviennent les sources d’un profond changement social et politique.


Les sociologues, d’Auguste Comte jusqu’à Raymond Aron dans les années 1960, ont voulu comprendre ce qu’était la société industrielle, puis Daniel Bell et Alain Touraine se sont penchés sur la société post-industrielle. Aujourd’hui Manuel Castells veut comprendre et nous faire comprendre la société de la communication et de l’informatique, la société des réseaux.

Les membres du Comité général des Prix Balzan sont toujours sensibles au fait que leurs enfants et petits-enfants sont collés à leurs instruments de connexion électronique et soucieux de comprendre eux-mêmes cette nouvelle société dans laquelle nous entrons. Votre activité, Manuel Castells, est exceptionnelle et nous avons confiance que le prix Balzan que la Fondation met à votre disposition vous permettra de prolonger les travaux que vous menez, répartis entre l’Espagne, les États-Unis et le Royaume-Uni. Dans la nouvelle société quantique vers laquelle nous nous dirigeons, nous sommes sûrs de pouvoir profiter de la façon dont vous la comprenez, dont vous nous l’expliquez et dont nous essayeron à notre tour de la comprendre.

« Pour avoir étudié de façon approfondie les conséquences de la grande révolution technologique de notre époque, à savoir la révolution numérique et les profonds changements sociaux et politiques qui découlent des nouvelles technologies de communication et de l’élaboration des informations à travers l’informatique, la microélectronique et l’internet et avoir proposé une théorie générale de la nouvelle société globale de l’information issue de ces techniques »...telle est la motivation du Comité général des Prix pour justifier l’attribution du Prix Balzan à Manuel Castells.

Manuel Castells

Researching the Network Society

In the last four decades, closely associated to the rise of a new technological paradigm in micro-electronics based information and communication technologies, we have observed the development of new communicative practices. Since meaningful communication is a fundamental feature of human species, the transformation of communication affects everything in human life, maybe (just maybe) inducing changes in the rewiring of our brains over time. After all, in humans all depends on the evolution of their
neural networks in interaction with their genetic heritage and their natural and social environment. From the history of technology we know that people adopt, use, and modify new technologies in ways appropriate to fit them into their needs and desires, depending on their culture, social organization, institutional environment and personality system. But there is also a specific effect of technology. In order for technologies to be adopted, used, and diffused they must be available at the time and place when their need is directly felt by humans and their organizations. Thus, there is synergistic interaction between technological discovery and social evolution and in this particular instance between the diffusion of digital communication and the rise of the network society.

At the heart of the scientific project that has guided my research in the last three decades is the attempt to study empirically the interaction between the new technological paradigm emerging from microelectronics-based information and communication technologies, and the evolution of individual behavior and social organization on a global scale.

I conducted this research at several levels:

- The transformation of the social structure, with the formation of a new type of society that I conceptualized as the network society.
- The effects of new information and communication technologies, particularly the Internet and wireless communication networks on individual behavior and on the culture of society. I also examined the interaction between cultural change and the culture of innovation that shaped the Internet, as in this case the users of the technology were also the producers of the specific form in which Internet and mobile networks evolved.
- The transformation of some essential domains of social relationships by the new forms of communication technology, with an emphasis on power relationships, politics and social movements.
- I integrated these different threads of empirical analysis in a grounded theory of social organization and social change that replaced the old theories of post-industrialism with a theory of the network society that included an understanding of the process of contemporary globalization, conceived as a global network of networks that link the core activities in every domain of human organization on a planetary scale.

My research has used diverse methodologies depending on the nature of the social processes under study: meta-analysis of secondary data, historical analysis, case studies, original survey research, interviews of key social and economic actors, focus
groups, network analysis, statistical analysis, and ethnographic observation. My approach was interdisciplinary and cross-cultural. I conducted my research personally in California, Spain, Russia, China, Japan, Finland, Chile and South Africa. I also used global data bases provided by my collaborators, such as the comparative surveys of the World Internet Project of the University of Southern California, the surveys of the Oxford Internet Institute, the surveys of the Lisbon-based Observatory of the Information Society, the American Life and Internet Project of the Pew Institute, in addition to my own surveys conducted between 2002 and 2007 in Catalonia and Spain by the Internet Interdisciplinary Institute that I directed. I included in my theory the cultural and contextual variation of the interaction between network technologies and the network society.

I will summarize my main findings in these different areas of inquiry referring to the publications that present these findings and their theoretical elaboration.

The study of the formation of the network society as the new social structure of the Information Age (the socio-technical form of social organization that superseded the Industrial Age) was originally presented in my book *The Rise of the Network Society* (Blackwell, 1996, with new editions in 2000 and 2010), and was further elaborated in my edited volume *The Network Society: a Cross-cultural Perspective* (Edward Elgar, 2004). The concept of the network society emerged from my observation of different domains of activity and in different contexts, as I discovered that networks were the prevalent form of social organization, with superior performing capacity using the versatility of new digital networking technologies. While networks are as old as mankind, digital technologies increased exponentially the capacity of the networking form of organization in terms of speed, interactivity, complexity and volume of information exchange to the point that the core activities in any realm of social organization are now constructed by and around networks.

Thus, our economy is a networked economy, both in terms of the macro-processes and in the operation of business firms. New communication and transportation technologies have allowed the formation of global networks that connect finance, production, distribution and trade throughout the planet, including in the networks every activity that is valued while disconnecting from the value-making networks those activities, populations, and territories that are devalued.

Capital is organized in globally interdependent financial markets that work in real time and transform every asset in securities using unprecedented computational capacity and computer networks managing high complexity at lightning speed. A new form of business has emerged: the network enterprise, as large corporations are internally decentralized, small business are networked among themselves and to the larger corpo-
rations, and the resources of companies are organized around business projects that are
enacted by evolving networks bringing together capital, labor, technology and market-
ing strategies. The networking form of organization has replaced the vertical bureau-
cracies of the self-contained large companies of the industrial age. And because net-
works have no boundaries, they connect across the firms and across the globe. The
network is the unit, the firms are the nodes, and the project is the operating system. A
similar form of organizational transformation driven by networking takes place in sci-
ence and technology, the key productive forces of our economy and society.

Labor follows this transformation of work, and is becoming increasingly individu-
alized and based on the ability of workers to reprogram themselves for constantly
changing tasks that require storage of knowledge and capacity to recombine this
knowledge for innovation, rather than specific skills that become rapidly obsolete.

Culture and information are being transformed by the revolution in media and
communication. Mass media are organized in global multimedia business networks,
and digital technologies allow the connection of different forms of communication,
both customized and globalized, with a growing interaction between mass communi-
cation (messages from one to many with little interactivity) and mass self-communi-
cation (multimodal messages in chosen time from many to many with relentless inter-
activity, based on Internet increasingly organized in wireless platforms).

In this fast changing world, governments and public sector organizations lag be-
hind technologically and culturally, and this gap between business, society, and insti-
tutions is at the source of new conflicts and contradictions between interest groups
and between generational cohorts.

Sociability is profoundly transformed in the network society by ubiquitous, per-
manent wireless connectivity and the massive access to the Internet (in 2013 2.8 bil-
lion users, as well as 6.9 billion mobile phone subscribers on the planet). Our society
is constructed around personal and organizational networks powered by digital net-
works and communicated by the Internet. This historically specific social structure
resulted from the interaction between the emerging technological paradigm and some
major socio-cultural changes. A primary dimension of these changes is what has been
characterized as the process of individuation, implying the decline of community un-
derstood in terms of spatial proximity, work, family and ascription in general. This is
not the end of community, and not the end of place-based interaction, but there is a
shift towards the reconstruction of social relationships, including strong cultural and
personal ties that could be considered a form of community, on the basis of individual
interests, values and projects. The process of individuation is not just a matter of cul-
tural evolution, it is materially produced by the new forms of organizing economic
activities, and social and political life as I described above. It is based on the transformation of space (megapolitan concentration and fragmentation), business and work (rise of the network enterprise), culture (shift from mass communication based on mass media to mass self-communication based on the Internet), crisis of the patriarchal family with increasing autonomy of its individual members, substitution of media politics for mass party politics, globalization as selective networking of places and processes throughout the planet. But individuation does not mean isolation. Sociability is reconstructed as networked individualism and community through a quest for like-minded individuals, in a process that combines on line interaction with off line interaction, cyberspace and the local space. Individuation is the key process in constituting subjects (individual or collective), networking is the organizational form constructed by these subjects, this is the network society, and the form of sociability is networked individualism. Network technologies are the medium for this new social structure and this new culture. This social structure is global; it is a global network society, as globalization is a network of networks, and as networks connect the space of places and the space of flows.

However, any new form of social organization and any process of major technological change generate their own mythology – in part because it comes into practice before scientists can assess their effects and implications, so there is always a time gap between social change and its understanding; in part also because the media tends to report bad news, and if possible, scary news. For instance, the use of the Internet would lead people to alienation, isolation, depression and withdrawal from society. In fact, my studies – and all the major surveys globally and nationally – show that the use of Internet increases sociability and decreases isolation and alienation, as face to face sociability and on-line sociability have a cumulative, positive effect on social interaction, friendship, family relationships, civic participation, citizen information and political engagement. So humans are not lonely; they are more connected than ever in a new form of sociability that sociologists have identified as networked individualism, since individuation is a major cultural attribute of our culture derived from the search for autonomy of humans vis-a-vis the institutions that constrain their desire for freedom.

This connection between the culture of the Internet and the search for autonomy was shown early on in my books The Internet Galaxy (Oxford University Press 2001) and La Transicion a la Sociedad Red (Barcelona 2007) and later in my analysis of the transformation of communication in my book Communication Power (Oxford 2009) as well as in my address to the Royal Society meeting in London on the occasion of the 350th anniversary of the Society on 28 September 2010.
The major social trend I have identified in my research, as presented in these books, is the growing emphasis by humans in constructing their autonomy vis-a-vis the institutions and organizations of society. They do so by defining their specific personal projects in interaction, but without submission, with the institutions of society. This is the case for a minority of individuals, but because of their capacity to lead and mobilize, they introduce a new culture in every domain of social life: in the economy (entrepreneurship), in the media (the active audience), in Internet (the creative user), in the market (the informed and proactive consumer), in education (students as informed critical thinkers, e-learning and m-learning pedagogy), in health (the patient-centred health management system), in e-government (the informed, participatory citizen), in social movements (cultural change from the grassroots, the rise of networked social movements), in politics (the independent-minded citizen able to participate in self-generated political networks). There is increasing evidence of the direct relationship between Internet and the rise of social autonomy, as shown in my research on Catalonia, based on a survey on a sample of 3000 individuals representative of the population at large. I built a scale of autonomy in different dimensions of social behavior: professional development, communicative autonomy, entrepreneurship, autonomy of the body, personal autonomy and socio-political participation.

These six types of autonomous practices are statistically independent among themselves, but they all correlate with the frequency and intensity of the uses of the Internet (Castells et al., *Transicion a la Sociedad Red*, Barcelona 2007). These findings are in cognitive coherence with the studies conducted by Michael Willmott at the British Computer Institute in 2010 showing, for 35,000 people across the globe, the positive relationship between Internet use and indexes of happiness. The study showed that Internet uses empower people, increasing their feelings of security, personal freedom and influence, which in turn have a positive effect on personal well-being. Available evidence from many sources also shows that the use of Internet increases sociability. Since sociability and empowerment are key factors in fostering individual happiness, the findings of Willmott and my own findings provide strong evidence in support of the social benefits of Internet use in the context of a culture in which the search for autonomy is paramount – a culture of autonomy that was the source of the technological design of the Internet by its pioneers in the 1970s.

In the 2000s, new forms of networked interaction emerged in the Internet, with the rise of social networking sites such as Friendster (the first one), Facebook, Baidu, Twitter, Linkedin, Twenty, Whatsapp, etc., whose viral diffusion has changed the landscape of human communication in all realms of activity, and particularly in sociability. In my book *Communication Power* (Oxford 2009), I analysed this transfor-
mation of communication. I showed that digital social networks are constructed by
users themselves building both on specific criteria of grouping (entrepreneurship in
creating sites, then people’s choice) and on broader friendship networks, tailored by
people themselves with different levels of profiling and privacy. The key to success
is not anonymity, but on the contrary, self-presentation of a real person connecting to
real persons. So, it is a self-constructed society by networking that connects to other
networks. But this is not a virtual society. There is a close connection between vir-
tual networks and networks in life at large. This hybrid world is a real world, not a
virtual world or a segregated world. People build networks to be with others, and to
be with others they want to be with on the basis of criteria, which includes those
people whom they already know (but a selected sub-segment). If we needed an an-
swer to what happened to sociability in the web world, here it is: there is a dramatic
increase in sociability, but on a different kind of sociability, facilitated and dynam-
ized by permanent connectivity and social networking on the basis of mobile com-
unication networks. In the book I published with my collaborators, *Mobile Com-
munication and Society* (MIT 2006), we showed that permanent, ubiquitous connec-
tivity creates an infrastructure of communication that overlays everything we do in
every domain and in every country, as we approach 7 billion mobile phone subscrib-
ers in the world. Social networking sites, usually accessed from wireless platforms,
are living spaces connecting all dimensions of people’s experience. This transforms
culture because people share, usually with a low emotional cost, saving energy and
effort. They transcend time and space, yet they produce content, set up links, and
connect practices. It is a constantly networked world in every dimension of human
experience. They co-evolve in permanent, multiple interactions. But they choose the
terms of their co-evolution.

Thus, people live their physical lives but increasingly connect on multiple dimen-
sions in SNS. Paradoxically, the virtual life is more social than the physical life, indi-
gualized by the organization of work and urban living. But people do not live a
virtual reality; indeed, it is a real virtuality, since social practices, sharing, mixing,
living in society is facilitated in the virtuality, in what I called time ago the space of
flows. Because people are increasingly at ease in the multi-textuality and multi-di-
mensionality of the Internet, marketeers, work organizations, service agencies, gov-
ernment and civil society are migrating massively to the Internet, less and less setting
up alternative sites, more and more being present in the networks that people construct
by themselves and for themselves, with the help of Internet social networking entre-
preneurs, some of whom become billionaires in the process, actually selling freedom
and the possibility of autonomous construction of lives. This is the liberating potential
of the Internet made material practice. The largest of these social networking sites are usually bounded social spaces managed by a company. However, if the company tries to impede free communication it may lose many of its users, because the entry barriers in this industry are very low. A couple of technologically savvy students with little capital can set up a site in the Internet and attract escapees from a more restricted Internet space, as happened to AOL and other networking sites of the first generation, and as could happen to other social networking sites if they were tempted to tinker with the rules of openness. So, SNS are often a business, but they are in the business of selling freedom, free expression, chosen sociability. When they tinker with this promise, they risk their hollowing by net citizens migrating with their friends to more friendly virtual lands.

I extended the study of the interaction between the Internet, mobile communication and the culture of autonomy to the realm of contemporary social movements. In my book Communication Power, published in 2009, I emphasized the rise of new forms of autonomous social mobilization in different countries, including Korea, Spain, Iran and the United States, by using the power of the Internet and mobile phone networks to bypass the control of political institutions and traditional political organizations. I proposed the hypothesis that these were embryos of the new social movements resulting from the characteristics of the network society. Then, in 2010-2013, these networked social movements materialized on a global scale, particularly in the Arab revolutions, in Iceland, in Spain, in the United States, in Brazil, in Turkey, and with lesser intensity, in thousands of cities of over one hundred countries. I conducted a first empirical study of the most salient of these movements, and I found a common pattern in spite of the diversity of cultural, economic and institutional contexts. I presented my findings and my elaboration of these findings in my book Networks of Outrage and Hope. Social Movements in the Internet Age, written and published in 2012 (Cambridge, Polity Press).

Summing up on my research on the network society, I showed that while the Internet, as all technologies, does not produce effects by itself, it has specific effects – powerful effects – in enhancing the capacity of the communication system to be organized around flows that are interactive, multimodal, asynchronous or synchronous, global or local, and from many to many, from people to people, from people to object, and from objects to objects, increasingly relying on the semantic web. How these characteristics affect specific systems of social relationships has to be established by scholarly research, and this is what my research, alongside the research by colleagues working in the new field of Internet studies, has tried to investigate for many years, following the Internet in its social and technological evolution. What is already clear
is that without the Internet, we would not see the large scale development of networking as the fundamental mechanism of social structuring and social change in every domain of social life. Internet, the World Wide Web and a variety of networks based on wireless platforms constitute the technological infrastructure of the network society as the electrical grid and the electrical engine were the support system for the form of social organization that we conceptualized as the industrial society. Thus, as all social constructions, the network society is an open-ended form of social organization that conveys the best and the worse in humankind. Yet, the global network society is our society, and the understanding of its logic on the basis of the interaction between culture, organization and technology in the formation and development of social and technological networks is a key field of research in the 21st century.

Beyond my specific contribution to the empirical and theoretical study of the network society, my research and teaching have developed for about five decades, and have investigated other themes. My first interest was in urban studies, first at the University of Paris, where as a young assistant professor I researched and wrote my first book *La Question Urbaine*, proposing a new theory of urbanization and spatial transformation; and at the University of California, Berkeley, where I wrote and published the field work research on urban social movements that I conducted for twelve years in the book *The City and the Grassroots* (Berkeley, 1983), which received the C. Wright Mills Award. Then I studied the interaction between technological change, economic restructuring and urban/regional development in the book *The Informational City* (Blackwell, 1989), which represents my transition from the study of urban processes to the study of the network society.

A second stream of research, still current, has been my interest in understanding socio-economic development, both in national contexts, and on the global scale. This includes my co-authored study with Pekka Himanen on Finland, focused on the interaction between the information society and the welfare state (Oxford, 2002); my study on the Chilean Model of Development (Santiago, 2005); the study I directed on the effects of mobile communication on development in Latin America (Barcelona, 2008); and my recent project on global development, co-directed with Pekka Himanen, to be published by Oxford in 2014 under the title *Reconceptualizing Development in the Global Information Age*.

I have also been active throughout my life in contributing to the creation of innovative science and research institutions. In particular, I have participated in the two major institutional initiatives launched by the European Commission in recent years in science and technology. I was a founding board member of the European Research Council (ERC) in 2005-2008, and a founding board member of the European Institute of Innovation and Technology (EIT) in 2008-2012. I was also a member of the Advisory Council on Information Technology and Development of the United Nations Secretary General, with Kofi Annan. I currently serve in the Scholars Council of the US Library of Congress, where I have been advising on the role of the Library in the context of Internet-based information processing.

My future research projects focus on the social dimensions of the current economic crisis in Europe and the US, the theme of the research that young researchers will conduct under my guidance using the generous Balzan Prize funding. My own new project, in 2014-2016, focuses on the multidimensional crisis of the European Union, examining the interaction between the financial crisis, the social crisis, the political crisis and the institutional crisis in the EU at large. It will be conducted from my chair at the College d’Études Mondiales, Maison des Sciences de l’Homme, Paris, in cooperation with the Gulbenkian Foundation and the University of Cambridge. And I will continue teaching full time at the Annenberg School of Communication, University of Southern California, in Los Angeles, and part time at the Department of Sociology, University of Cambridge – because my students have always been my source of learning, inspiration and joy, and I will continue to work with them as long as I can be helpful to their blossoming as autonomous thinkers.

Questions and Comments

Heinz Gutscher

Thank you very much for a very fascinating presentation. As a social scientist, I would have many questions, but I think that from the audience, too, there will be questions.

Alberto Quadrio Curzio

You said that you have done quite a lot of groundwork research, and you have brought to our attention the situation of Northern Italy, where there are these networks of small firms, and you said that firms are legal entities, while a network is not a legal entity. Now, in Italy there is a law of 2009 which allows networks or firms to be legal
entities, and the number of network firms as legal entities is continuously increasing.
I think that this might be useful information for you.

Talking about Italy, we have an interesting situation now, or an “experiment”, on
which I would like to hear your opinion. As you know, we have a political movement
called the Grillo Movement, Cinque Stelle, which is run by Internet. Orders are given by
Internet to people who are in the Parliament, and they have to execute these orders.
What do you think about this kind of new political organization which doesn’t seem to
increase democracy, because the people who give the orders are just two. And those who
execute the orders are members of Parliament. What kind of new democracy is that?

And finally, I think that from an economic point of view, the network innovation
has been less important than from the point of view of promotion processes. In fact,
when you think about real economic systems or systems of production they are always
rooted somewhere. When you have to produce something, you might connect produc-
tion in very different places, but in the end you have to put all the pieces of production
together, so the real economy is always grounded somewhere.

Manuel Castells

Thank you. Well, first of all, as a social scientist, it’s very important – at least for me
– not to have normative judgments. I can do it as a citizen, I can do it as a person, but not
in an academic environment. I never do it; I never do it in my classes. So what one can
say about the Cinque Stelle movement is – in terms of what you say – two things.
First, it has been very effective as a form of organization, coming from nowhere to
obtain – in the 2013 Parliamentary election – 26.1% of the Italian vote. And actually,
in terms of direct voting expression, becoming the first party of Italy from nowhere,
in terms, one can say, of political effectiveness, it’s very effective, even if later on in
the municipal elections, it fell quite substantially. But it still plays a major role in Ital-
ian politics, coming literally from nowhere.
Second, about what you said in terms of the leadership of Beppe Grillo and his
associates in the advertising industry, they are really a contradiction, because these
new social movements based on the Internet are characterized fundamentally by hori-
zontal networking and by the absence of designed leaders – in general, on the whole.
And in fact, that’s part of their ideology. The ideology is that we don’t want the institu-
tions; we don’t want a political party; we don’t want union; we just want people to
network among themselves according to the model of network individualism that I
mentioned before.

Well, in that particular case of Italy, there is – you’re absolutely right – a horizon-
tal networking, but then two people on the top of the network, who issue unilateral
instructions to the network. That’s a fundamental contradiction, and in terms of the analysis of the point of view of the social sciences – we can think that contradiction will probably make it impossible for that movement to stabilize either as a political movement, as a social movement or as a political party. At one point, it will probably become a political party, and at that moment, it will lose some of its specific appeal.

Now in terms of the economy, there I am not so sure. Look, a central part of the economy – absolutely central – is capital markets. That’s central, and that’s not the real economy, the rest is not the real economy, the more real economy is the financial economy. Quite fundamentally, even if we cannot touch it, the real economy is where capital is invested, is where all our money is, where all our savings are. Banks don’t have our money. The money is in the global network of financial markets and constantly changing in terms of value. So the notion that the economy is purely the material production of the economy, I challenge that, and in that sense, the most important assessment of our globalized economy is the financial markets, which are pure networks. But I would go even farther. I would say that even material production – it’s also extremely important – is also made of networks. I was the first to analyze the map of the electronics industry, starting in California, and in fact, Silicon Valley cannot be understood without Hsinchu in Taiwan, cannot be understood without the connections with Munich. So ultimately, you have to assemble something here, but this assemblage takes place in different sites in the world, depending on the location or on the advantage of one or another place. So we are, even in material production, in a completely networked economy – multi-location, you’re right, you need to locate someone – but the location is multiple, and the unit of all this processing is the network, not the location.

*Heinz Gutscher*

Thank you, Professor Castells, I will give the floor now to Karlheinz Stierle, member of the Balzan General Prize Committee, who will present prizewinner André Vauchez.
Présentation d’André Vauchez, lauréat Balzan 2013 pour l’histoire du Moyen Âge

Karlheinz Stierle, membre du Comité général des Prix Balzan ; membre de la Heidelberger Akademie der Wissenschaften ; correspondant de l’Académie des sciences morales et politiques, Paris, membre étranger de l’Accademia Nazionale dei Lincei

C’est aujourd’hui un jour de gloire pour la recherche française parce que sur quatre prix trois ont été attribués à des savants français et en hommage à ces trois chercheurs je parlerai français. Après les discussions que nous avons suivies nous nous sommes rendu compte que nous vivons dans des mondes différents et comme ils sont différents, il est difficile d’établir une relation entre ces mondes. Nous devons vivre une vie compliquée entre ces dimensions de la réalité qui s’élargissent. Toutefois, ces dimensions qui s’élargissent ne doivent pas nous faire perdre de vue que nous avons tous une histoire commune qui est à la fois une histoire européenne basée sur l’antiquité, mais aussi une histoire basée sur le Moyen Âge. « Moyen Âge » est une expression étrange, parce que Medium Aevum au début ne voulait rien dire, c’était un espace vide qui était donné à la damnatio memoriae. Pétrarque voulait éliminer les souvenirs du Medium Aevum parce qu’il s’agissait de l’époque des empereurs illégitimes, des empereurs allemands. C’était une époque à effacer, et la Renaissance a continué ce projet. Heureusement, grâce aux historiens romantiques du dix-huitième siècle nous avons commencé à redécouvrir la réalité de cette époque que, fausserement, nous avons appelée Medium Aevum et où il nous reste toujours à découvrir de nouvelles dimensions fascinantes.

André Vauchez s’est lancé dans ce travail de recherche avec une ingéniosité, une patience et une lucidité exemplaires. André Vauchez est Professeur émérite d’histoire du Moyen Âge à l’Université de Paris-Ouest Nanterre, mais il est aussi membre de l’Académie des inscriptions et belles lettres, dont il a été Président, et surtout il a été directeur, de 1995 à 2003, de l’École française de Rome. Il représente la liaison entre la recherche italienne et la recherche française du Moyen Âge. Son œuvre, d’une remarquable cohérence, est centrée sur le phénomène de la spiritualité qui a très profondément marqué la mentalité du Moyen Âge en Occident. Avec une rigueur magistrale André Vauchez éclaire les nombreux aspects de la spiritualité dans le cadre parfois conflictuel de l’institution religieuse et de la religiosité populaire, montrant en particulier leur enracinement dans la vie quotidienne médiévale.

Le Prix Balzan lui a été décerné pour ses études novatrices sur la spiritualité médiévale dans la chrétienté occidentale et son enracinement dans la vie quotidienne du Moyen Âge, pour ses recherches sur les conceptions de la sainteté médiévale et sur la
sacralisation de l’espace et du temps, pour sa contribution à une meilleure comp-
préhension de la piété et de la religiosité monastique et féminine, pour sa profonde
connaissance et sa magistrale présentation de la vie, de l’œuvre et du rayonnement de
François d’Assise.

Avec son ouvrage *La spiritualité du Moyen Âge occidental* (1975), puis ses études
sur les idéaux de perfection promus par la papauté et leur réception par les fidèles dans
*La sainteté en Occident aux derniers siècles du Moyen Âge* (1198-1431), publié en
1981, et sur la religiosité laïque dans *Les laïcs au Moyen Âge* (1987), Vauchez em-
brasse tout l’espace temporel de cette époque, illustrant ainsi les dynamiques de la
spiritualité médiévale et de ses formes d’expression. Dans son livre *Saints, prophètes
e et visionnaires : le pouvoir surnaturel au Moyen Âge* (1999), il tente de comprendre,
tout en gardant une distance critique, l’un des aspects du Moyen Âge que nous avons
longtemps refoulé et que nous ne faisons que survoler aujourd’hui en le taxant de pure
superstition.

L’ouvrage collectif en italien *Esperienze religiose nel Medioevo* (2003), avec ses
recherches monographiques innovantes et toujours riches en contenus sur « la sainteté
des laïcs », « la sainteté féminine », « l’homme médiéval et le sacré : lieux de ren-
contre », et « le temps et l’espace dans la religiosité médiévale », crée sans cesse de
nouvelles passerelles entre la spiritualité et sa « place dans la vie ».

Mais le sommet des explorations d’André Vauchez dans le domaine de la com-
préhension de la religiosité médiévale est représenté par son ouvrage *François
l’influence de saint François d’Assise parvient, en évitant les anachronismes, à rendre
vivante l’une des figures les plus influentes du Moyen Âge, qui a profondément mar-
qué l’imaginaire collectif ; mais en même temps il analyse les mythes qui se sont
formés autour de cette grande figure et leur évolution du Moyen Âge à nos jours.

En vous félicitant, je vous donne la parole, M. Vauchez.

**André Vauchez**

**Des saints aux sanctuaires. Recherches sur la spatialisation du sacré dans
l’Occident médiéval**

Merci infiniment pour ce rapport. Si vous permettez, je continuerai en français
puis cette langue a encore quelque titre, au moins dans le secteur des sciences
humaines, et d’autre part, comme nous sommes en Suisse, il s’agit d’une langue of-
ficielle de la Confédération. Quand j’ai appris il y a quelques semaines, que j’ai été
jugé digne de recevoir le Prix Balzan pour l’histoire du Moyen Âge, j’en ai évidemment été très heureux et plein de gratitude pour les instances et les personnalités scientifiques qui m’avaient fait ce grand honneur. J’ai également apprécié, lorsque j’ai reçu des informations plus détaillées quelques jours plus tard, de voir qu’avant de recevoir cette récompense j’allais devoir subir un examen de passage, le dernier sans doute avant le jugement dernier qui nous attend tous, mais cela m’a permis de me rajeunir, de me sentir comme un jeune étudiant, soucieux d’obtenir votre indulgence et peut-être, mais c’est moins sûr, de vous convaincre du bilan des recherches que j’ai menées et du programme de recherche que j’avais l’intention de développer grâce au Prix Balzan, surtout en collaboration avec mes anciens élèves dont la plupart sont aujourd’hui professeurs d’université et chercheurs confirmés. Ce bilan et ce programme je les ai intitulés Des saints aux sanctuaires. Recherches sur la spatialisation du sacré dans l’Occident médiéval.

Entre 1965 et le début des années 1990, mes recherches ont été consacrées pour l’essentiel à l’histoire de la sainteté dans l’Occident médiéval. Cette orientation s’inscrivait dans le cadre d’un intérêt nouveau pour les sources hagiographiques - Vies de saints, recueils de miracles, récits de translation de reliques - négligées jusqu’au milieu du XXe siècle par les historiens positivistes qui les jugeaient peu fiables. Contemporains de ceux de Peter Brown sur l’Antiquité tardive, lauréat du Prix Balzan en 2011, et de Frantisek Graus et Sofia Boesch Gajano sur le Haut Moyen Âge, mes travaux ont contribué à une réévaluation de l’importance de ces sources pour la compréhension de l’histoire des mentalités et de la vie religieuse à l’époque médiévale. Dans mon livre sur La sainteté en Occident aux derniers siècles du Moyen Âge, paru en français en 1981 et, peu après, en italien et en anglais, j’ai mis en évidence l’intérêt exceptionnel que présentent les procès de canonisation organisés par la papauté à partir de la fin du XIe siècle pour vérifier la réputation de sainteté (fama sanctitatis) des serviteurs de Dieu auxquels le peuple chrétien rendait spontanément un culte. Assez sommaires à l’origine, ces derniers donnèrent naissance, à partir du milieu du XIIe siècle, à des enquêtes de plus en plus développées qui allaient devenir pour l’Église romaine un moyen de contrôler la dévotion populaire et les cultes locaux. En effet, la sainteté était alors moins considérée par la plupart des fidèles comme un ensemble de vertus morales que comme un pouvoir d’origine surnaturelle, qui se manifestait par des miracles, attribué à un « homme de Dieu » (vir Dei) ayant eu une existence et une fin exemplaires. L’étude de ces procès, dont la plupart étaient encore inédits dans les années 1970, m’a permis de souligner la présence simultanée de plusieurs conceptions de la sainteté au sein de la chrétienté occidentale (modèle royal, modèle « martyrial » illustré parfois par des images plus encore que par des textes, idéal de
perfection monastique) et leur évolution entre le XIIIe siècle et le début du XVe, avec l’apparition des ordres Mendiants issus de S. François d’Assise et de S. Dominique, la naissance d’une sainteté des laïcs sous l’influence du mouvement pénitentiel, et l’« invasion mystique » des XIVe et XVe siècles. Celle-ci se traduit par une multiplication du nombre des visions et des révélations prophétiques, surtout parmi les femmes, comme l’illustrent les noms de Brigitte de Suède (1373) et de Catherine de Sienne († 1380), à laquelle j’ai prévu de consacrer un livre en 2014. La réflexion approfondie que j’ai menée sur ces questions m’a amené à élaborer la notion de « pouvoirs informels » pour désigner l’influence exercée de leur vivant et après leur mort par des personnages et des mouvements charismatiques dans l’histoire religieuse et politique du Moyen Âge, de François d’Assise à Savonarole, en passant par des figures moins connues, comme celle du franciscain contestataire et millénariste Jean de Roquetaillade, qui vécut et écrivit dans les prisons pontificales d’Avignon entre 1349 et 1366 et dont j’ai publié le Liber ostensor – « le Livre révélateur » – avec le concours d’une équipe franco-suisse. Une partie de ces recherches ont conflué dans un recueil d’études intitulé Saints, prophètes et visionnaires. Le pouvoir surnaturel au Moyen Âge (Paris, 1999), mais j’ai encore quelques chantiers en cours dans ce domaine : tout d’abord l’édition critique des Vies médiévales et l’histoire du culte de S. Homebon (Omobono) de Crémone († 1197), le premier saint laïc non noble à avoir été canonisé – c’était un artisan et un marchand – qui devait devenir à partir de la fin du Moyen Âge le patron des drapiers dans la plus grande partie de la chrétienté latine. Il reste aussi à éditer certains procès de canonisation du Moyen Âge, comme ceux de l’archevêque de Bourges Philippe Berruyer, un contemporain de saint Louis, et de sainte Rose de Viterbe († 1251), et j’espère pouvoir y contribuer car ce sont des documents d’un extrême intérêt. De même, je voudrais publier divers textes prophétiques médiévaux en latin et traduire en français certains d’entre eux afin de rendre accessible – au moins sous forme d’anthologie – cette littérature pleine de visions et de passions, encore largement méconnue.

A partir des années 1995, mes recherches ont surtout porté sur les sanctuaires sur lesquels j’ai lancé des enquêtes visant à mettre en lumière leur importance dans la vie religieuse, mais aussi dans la structuration du territoire et de l’espace urbain. Des saints aux sanctuaires le passage était logique et assuré par la présence dans ces derniers de reliques ou de traces d’interventions surnaturelles, qu’il s’agisse de celles de saint Michel archange ou de la Vierge Marie. Dans la ligne d’Alphonse Dupront dont l’enseignement et les livres m’ont beaucoup marqué, je me suis intéressé à ces lieux saints innombrables, tant en Orient qu’en Occident, qui sont devenus des sanctuaires chrétiens et des buts de pèlerinage, moins en raison de leurs particularités physiques.

Aujourd’hui le moment me semble venu de prendre un peu de recul par rapport à ces enquêtes « de terrain » et d’approfondir ma réflexion sur la notion même de sanctuaire en essayant de revenir sur quelques interrogations fondamentales : qu’est-ce qu’un sanctuaire ? Quelles ont été leurs principales fonctions aux diverses périodes de l’histoire? Comment peut-on mesurer leur rayonnement? Avant d’aller plus loin, je me permettrai de rappeler quelques définitions, ne serait-ce que pour en tester la validité. L’existence de sanctuaires est évidemment liée au phénomène religieux, c’est-à-dire aux relations entre l’ici-bas et l’au-delà, entre l’homme et Dieu ou ses dieux. Le sanctuaire peut être un lieu de culte (pensons aux temples égyptiens ou à celui de la Jérusalem biblique, desservis par des cohortes de prêtres et de sacrificateurs), mais il est généralement plus que cela et c’est précisément ce « plus » qu’il s’agit de définir.
En prenant la question par l’autre bout, nous dirons que tout lieu de culte n’est pas un sanctuaire, même s’il arrive souvent que l’on fasse un usage inapproprié de ces termes en les employant de façon indistincte. Dans le domaine chrétien en tout cas, une simple église paroissiale ne présente pas les caractéristiques du sanctuaire, dès lors qu’elle est uniquement le lieu du culte liturgique et d’une pratique sacramentelle ordinaire, tandis que Saint-Pierre de Rome ou Saint-Siméon, en Syrie, en sont incontestablement. Il y a dans le sanctuaire une relation particulière au sacré, qui passe par des objets, qu’il s’agisse de la tombe réelle ou prétendue d’un homme de Dieu, ou de simples reliques, ou encore de la trace visible d’une théophanie ou d’une « mariophanie » dont les légendes de fondation font souvent état. On peut donc définir le sanctuaire, dans une première approche, comme un lieu sacré où se produisent ou se sont produits des phénomènes considérés comme surnaturels (miracles, guérisons et diverses formes d’inspiration), et qui se distinguent par leur pouvoir d’attraction sur une aire géographique qui peut être locale, régionale ou internationale. A toutes les époques, les grands sanctuaires ont suscité en effet des pèlerinages qui y faisaient périodiquement affluer de grandes foules. Aussi ont-ils un lien avec la « religion populaire », pour reprenant une formule qui a été très à la mode dans les années 1970 et a suscité alors de nombreuses recherches. Même si elle a été parfois galvaudée, cette expression peut encore être utilisée dans beaucoup de cas, à condition toutefois de bien se rendre compte que le populaire est souvent du « popularisé » et que les pouvoirs politiques et sacerdotaux ont dans la plupart des cas joué un rôle non négligeable dans la gestion des sanctuaires et dans leur évolution.

Une autre notion souvent appliquée aux sanctuaires nécessite une clarification préalable : celle de leur rayonnement. Les sanctuaires émettent en effet leur influence sur un territoire donné, plus ou moins étendu et certains, comme ceux du Mont-Athos dans la chrétienté orthodoxe ou de Saint-Pierre au Vatican, ont même donné naissance à des entités territoriales autonomes. Mais la référence au seul territoire s’avère trop restrictive et sans doute vaut-il mieux parler de zone d’attraction. Le sanctuaire en effet est déjà en lui-même un territoire à part (sanctus en latin), découpé (téménos en grec) dans le paysage naturel ; c’est une portion d’espace sacré bien délimitée, même si ces limites peuvent fluctuer au fil du temps. Ce lieu particulier n’appartient pas aux hommes mais à la divinité qu’on y vénère. Aussi s’agit-il d’un espace inviolable (sacer) et ceux qui y réfugiaient, dans l’Antiquité comme au Moyen Âge, bénéficiaient du droit d’asile. Les hommes se sont efforcés de faire de ces sanctuaires des espaces de paix et de réconciliation, ou au moins de contact, comme on le voit avec les sanctuaires de confins qui marquaient l’entrée dans le territoire d’une communauté humaine, qu’il s’agisse d’un peuple ou d’un village, et constituaient également des
lieux d’échange où l’on s’efforçait de régler pacifiquement les conflits de voisinage et où l’on procédait à des échanges commerciaux à l’occasion d’une foire annuelle. N’oublions pas en effet que, dans les religions « traditionnelles », une des fonctions essentielles de la regligio consiste à penser, organiser et contrôler l’espace, en bref à assurer une gestion rituelle du territoire.

Dans une religion comme le christianisme et surtout le catholicisme où le clergé tient une place prépondérante, le rôle historique joué par les sanctuaires a été de permettre aux fidèles d’avoir un accès direct au surnaturel, sans avoir à passer par les médiations institutionnelles. D’où le succès actuel des pèlerinages et des itinéraires sacrés : si la pratique religieuse dominicale a connu en Europe depuis un demi-siècle une chute considérable, on voit parallèlement des jeunes et des moins jeunes partir chaque année plus nombreux sur les chemins de Saint-Jacques de Compostelle ou de Saint-Michel, ou faire à pied le tour des sanctuaires franciscains de l’Ombrie, dans le cadre d’une pratique nouvelle que les sociologues des religions désignent sous le nom de « religion à la carte ».

Pour se faire une idée précise de cette réalité, il convient cependant de considérer les sanctuaires dans une perspective hiérarchique. On ne peut mettre en effet sur le même plan un sanctuaire local, qui n’accueille des pèlerins qu’une fois l’an à l’occasion de la fête du saint patron, et se signale simplement par la présence de quelques ex voto autour d’une image sainte, et les grands sanctuaires comme Lourdes ou San Giovanni Rotondo où passent tout au long de l’année des millions de visiteurs. Dans le monde méditerranéen et les régions voisines, il existe même des « villes-sanctuaires » comme Jérusalem, La Mecque, Rome, Assise ou Loreto – mais aussi, dans le passé, Karnak-Louxor ou Epidaure – dont le développement et la prospérité étaient et sont encore étroitement liés à la vie des sanctuaires qui s’y trouvent. Il conviendra aussi de s’interroger sur la typologie de ces derniers, qui est très variée et a pu évoluer au cours des siècles : si la quête du recours y est partout présente, certains d’entre eux ont une fonction thérapeutique plus marquée, tandis que d’autres sont des lieux principalement voués à la dévotion ou à la pénitence, sans parler du rôle politique et économique qu’ils ont pu être amenés à jouer à une époque donnée.

Enfin, l’étude de l’évolution des sanctuaires dans la longue durée sera un des axes principaux des recherches que je souhaite mener et encourager dans les années à venir. En effet, les historiens ne doivent pas oublier que les sanctuaires, comme les civilisations, sont mortels. Tous ne sont pas immémoriaux, tant s’en faut, comme celui d’Ysé, au Japon, que l’on reconstruit tous les vingt ans de la même façon depuis la nuit des temps. Bien souvent, après une phase de jaillissement qui les a conduits à un apogée, nombre d’entre eux ont connu le déclin et sombré dans l’oubli, tandis que d’autres
naissaient et se substituaient à eux. Dans la réalité, les choses sont encore plus complexes, car certains sanctuaires qui semblaient avoir perdu leur capacité de rayonnement l’ont parfois retrouvée longtemps après de façon inattendue, à la faveur d’une « recharge sacrée », pour reprendre une expression chère à Alphonse Dupront. L’étude de la géographie des sanctuaires est donc étroitement liée à celle de leurs vicissitudes historiques, qui appelle des investigations toujours difficiles en l’absence d’une documentation spécifique. Heureusement, les données fournies par l’archéologie permettent parfois de combler les lacunes des sources écrites.

Du point de vue méthodologique, l’étude des sanctuaires pose des problèmes délicats dans la mesure où, hier comme aujourd’hui, le lieu où il se trouve est parfois aussi important que l’intercesseur qu’on y vénère. Dans cette perspective, Alphonse Dupront a distingué ceux qui se sont développés dans des lieux « historiques », liés en général à la présence des reliques ou de la tombe d’un serviteur ou d’une servante de Dieu, et ceux qui sont situés dans des lieux « cosmiques », qui produisent une forte impression sur le visiteur en raison de leur situation pittoresque ou de leur insertion dans un cadre naturel particulièrement austère, ce que les Romains désignaient sous le nom de loca horrida. En réalité, les plus grands sanctuaires possèdent souvent ces deux caractéristiques, ce qui fait d’eux des lieux privilégiés : que l’on pense par exemple à celui de Saint Michel au Monte Sant’Angelo, dans le Gargano, où l’on trouve à la fois un site naturel extraordinaire et la marque du pied de l’Archange, qui aurait laissé cette trace dans le rocher lors de son apparition, ou encore à la grotte de Lourdes depuis le milieu du XIXe siècle. Dans le monde chrétien, comme du reste dans l’Antiquité « païenne », l’apparente homogénéité des titulatures – c’est-à-dire des noms des saints auxquels sont dédiés les sanctuaires – ne doit pas faire illusion : il existe dans les pays méditerranéens des milliers de sanctuaires, de toute taille, dédiés à la Vierge Marie, mais la « Madonna del Sasso » de telle localité italienne n’a rien à voir, aux yeux de ses dévots, avec la « Madonna del Soccorso » qu’on vénère dans un village voisin ; et la Vierge de Montserrat est très différente de celle de Loreto, qui fut relayée dans toute l’Europe catholique, au cours des XVIe et XVIIe siècles, par des sanctuaires ad instar où l’on retrouve l’image de la « Santa Casa », que des anges, selon une légende tardive, auraient apportée de Nazareth en Italie centrale par la voie des airs… Aux yeux de ses fidèles, si la divinité a choisi de se manifester en un lieu, c’est d’abord pour la communauté locale et pour ses membres, qui doivent être les principaux bénéficiaires de sa bienveillance, comme j’ai pu le constater de mes propres yeux au Liban il y a quelques années, à la suite d’apparitions mariales survenues dans un village de la Bekaa autour de 2002, où le prêtre nous raconta que ses paroissiens et surtout le chef du village ne laissaient à l’Eglise qu’une faible part des of-
franches et des revenus liés au pèlerinage qui attirait là depuis peu de nombreux visiteurs, tant chrétiens que musulmans. À ce titre, les sanctuaires sont, à tous les niveaux, des révélateurs de particularismes : un groupe humain, une ethnie, un peuple se reconnaissent en lui et parfois même s’identifient à lui : le lion de saint Marc, omniprésent sur les rives et dans les îles de l’Adriatique, renvoie certes à l’évangéliste mais surtout à la grande basilique qui abritait ses reliques et, en dernier ressort, à Venise qui était le centre de son culte en Occident ; et nul n’ignore l’importance des sanctuaires fédéraux ou confédéraux dans l’Antiquité grecque et latine, ou encore le rôle joué par le pèlerinage au temple de Jérusalem ou à La Mecque dans l’affirmation d’une appartenance au peuple juif ou à l’umma musulmane. En ce sens, on peut dire que les sanctuaires sont des marqueurs d’identité religieuse et politique, comme le montrent bien des phénomènes de continuité et parfois de superposition en un même lieu qui se sont produits à l’occasion de l’apparition d’une nouvelle religion ou confession. On le voit bien à Jérusalem où, après la conquête musulmane de 632, la mosquée d’Omar, construite sur l’esplanade du Temple dit de Salomon, vint concurrencer le Saint-Sépulcre, ce qui fit de cette ville une cité-sanctuaire commune aux trois religions du Livre, qui n’ont pas cessé depuis lors de s’en disputer le contrôle.

Mes recherches italiennes des années 1995-2003 m’ont permis de mettre en évidence l’existence d’une inflexion sensible dans l’histoire des sanctuaires entre le Xe et le XIIe siècle. Comme d’autres études effectuées en France médiévale par Michel Lauwers et Dominique Iogna-Prat ont abouti à des résultats identiques, je pense qu’on a affaire à un processus assez général à l’échelle de l’Occident, que j’ai appelé la spatialisation du sacré. De quoi s’agit-il ? Pour faire bref et de façon assez schématique, disons que l’on vit alors s’affirmer au sein de la chrétienté une tendance marquée à la constitution d’espaces sacrés, qu’il s’agisse des « sauvetés » que les Clunisiens cherchèrent alors à constituer autour de leurs monastères ou de nouveaux sanctuaires, de caractère local ou régional. Jusqu’à l’époque carolingienne en effet, les lieux réputés saints et attirant les pèlerins en grand nombre étaient peu nombreux : dans l’Antiquité tardive et le Haut Moyen Âge, l’église la plus prestigieuse était celle de l’Anastasis à Jérusalem, élevée par Constantin sur le lieu présumé du tombeau du Christ. Pour se rapprocher à ce mémorial de sa Passion et de sa Résurrection, on construisit tout au long du Moyen Âge de nombreuses églises ad instar Sancti Sepulchri qui en reproduisaient le plan circulaire et parfois même la topographie, comme les « Sacri Monti » construits par les Franciscains en Toscane et dans les régions alpines à partir du XVe siècle. A côté de cette référence fondamentale à Jérusalem et à la Terre Sainte qui fut à l’origine de toute une géographie imaginaire, il faut faire une place au culte des martyrs, en particulier celui des apôtres Pierre et Paul, dont les reliques et les basiliques
qui les abritaient attirèrent à Rome des flux de visiteurs qui s’accrurent après la conversion au christianisme des peuples anglo-saxons et scandinaves. Et, dès le VIIe siècle, nombre de visiteurs continuaient leur chemin en direction du mont Gargan où se trouvaient la grotte et le sanctuaire de saint Michel archange. Si, enjambant quelques siècles, nous observons la géographie religieuse de l’Occident autour de 1200, nous nous trouvons confrontés à une situation bien différente, caractérisée par l’existence d’un nombre beaucoup plus élevé de sanctuaires, souvent reliés les uns aux autres par des itinéraires sacrés comme la Via Francigena – du Nord des Alpes à Rome – prolongée jusqu’au Gargano par la « Via dell’Angelo » – et les chemins de Saint-Jacques de Compostelle qui ont fait couler tant d’encre. Ces routes étaient parcourues par des foules de pèlerins qui cheminaient d’un sanctuaire à l’autre dans l’espoir d’y obtenir la guérison de leurs maux et la rémission de leurs péchés. On assiste alors à la mise en place d’une nouvelle géographie religieuse de la chrétienté, pensée et vécue à partir des croisades et de la Réforme grégorienne comme un espace homogène, structuré autour d’un certain nombre de lieux sacrés qui constituaient autant de pôles d’attraction et de protection pour les hommes et les femmes de ce temps. La nouveauté majeure à ce niveau réside surtout dans la popularité croissante des sanctuaires de la France méridionale : pensons à Sainte-Foy de Conques, Rocamadour, Saint-Guilhem le Désert, Saint-Gilles du Gard, Notre-Dame du Puy, Vézelay et à tant d’autres encore qui attiraient les foules et que je voudrais étudier maintenant de façon plus approfondie dans les années qui viennent.

Parallèlement je souhaiterais envisager de plus près le processus mental qui porta les hommes de ce temps à voir dans chaque pèlerin un personnage sacré, une image du Christ « pèlerin d’Emmaüs » qu’on commence à représenter dans l’art roman ; parfois même, s’il venait à mourir en chemin, on le vénérerait comme un saint, comme je l’ai montré en étudiant les origines du culte de saint Roch au XVe siècle. C’est dans ce contexte mental qu’il faut situer l’importance croissante prise par le pèlerinage dans la vie religieuse des fidèles. Certes, les témoignages relatifs à des pèlerins qui s’étaient rendus en Terre Sainte ou à Rome sont assez nombreux dans les sources de l’Antiquité tardive et du Haut Moyen Âge. A l’époque carolingienne et ottonienne, il s’agissait surtout de Grands de ce monde (évêques et abbés, dignitaires laïcs) qui se rendaient à un sanctuaire lointain entourés d’un petit groupe de fidèles et rapportaient de leur voyage des objets précieux : reliques, tissus orientaux, ivoires, gemmes. Mais, autour de l’an Mille, le pèlerinage change de nature et ceux qui effectuaient ces déplacements dans un but religieux n’étaient plus les mêmes qu’auparavant : les pèlerins deviennent alors très nombreux et, parmi eux, la composante laïque et même populaire prévalut sur les clercs et les moines. Au XIIe siècle...
cles, saint Anselme et saint Bernard rappelèrent à ces derniers que leur monastère constituait pour eux la véritable Jérusalem et qu’il était inutile, voire dangereux, pour eux d’en sortir pour se rendre en Terre Sainte ou ailleurs. Dès lors le pèlerinage constituera un élément essentiel d’une religiosité et d’une spiritualité laïques, comme je l’ai montré dans un certain nombre d’études fondées sur l’étude des Vies de quelques saints laïcs, de Rainier et Bona de Pise à Facio de Crémone. Mais ce qui vaut pour l’Italie se vérifie-t-il également en France ? Des recherches plus poussées sur les sanctuaires et les pèlerins français entre le XIe et le XVe siècle devront être lancées pour s’en assurer. Je compte m’atteler à cette tâche dans les années qui viennent, en collaboration avec l’équipe qui s’est constituée dans ce but autour de Catherine Vincent à l’université de Paris-Ouest Nanterre.

Plus largement, je suis convaincu que cette approche « spatiale » et territoriale des sanctuaires et des pèlerinages devrait contribuer à renouveler l’histoire de la vie religieuse en Occident. Dans ce domaine l’historiographie s’est en effet concentrée essentiellement, dans les dernières décennies du XVe siècle, sur l’étude des structures ecclésiastiques (paroisses, « pievi », diocèses, ordres religieux) qui est certes fondamentale mais risque de faire croire que les hommes et les femmes du Moyen Âge étaient des sédentaires enfermés dans leur village ou leur quartier, qui n’auraient eu ni l’envie ni la possibilité de sortir de leur « encellulement ». Cette vision statique de la société médiévale néglige le fait que la mobilité des populations et des personnes y tenait une place très importante. Comme Alphonse Dupront l’a bien montré, le désir de se déplacer et de se mettre en quête d’une via salutis a été à l’origine de ces mouvements de foule suscités par les croisades, les jubilés et toutes les formes de « pèlerinage panique », pour reprendre une expression qui lui était chère. Mais cette polarisation sacrée de l’espace ne concerne pas seulement les grands ébranlements collectifs ou les visites aux principaux lieux saints de la chrétienté sur lesquelles les sources médiévales nous donnent d’abondantes informations. Elle vaut aussi au niveau de la vie quotidienne, qu’il s’agisse des déplacements effectués par les simples paysans comme par les Grands de ce monde pour se rendre à des sanctuaires thérapeutiques proches de leur résidence, ou du rôle joué par les sanctuaires de confins où des populations rurales se rencontraient une fois l’an à l’occasion de la fête d’un saint pour régler leurs litiges et éventuellement trouver des conjoints en dehors de la « tribu » pour les filles à marier et les garçons en âge de se « mettre en état », comme on disait alors. Ces micro-sanctuaires, dont on trouve l’équivalent en ville dans certaines chapelles, oratoires ou images saintes auxquelles on attribuait un pouvoir d’intercession, sont beaucoup plus difficiles à saisir et à étudier, faute, le plus souvent, d’une documentation adéquate. C’est pourtant dans cette voie que je voudrais...
m’engager davantage que je ne l’ai fait jusqu’à présent, afin de saisir dans sa réalité concrète et vécue l’importance des sanctuaires dans une société où la supplication et le recours constituaient des démarches indispensables pour assurer la survie des individus et des collectivités.

Questions et commentaires

Heinz Gutscher

Je vous remercie, Monsieur Vauchez, de cette présentation fascinante. Je me rends compte qu’il y a plusieurs personnes qui aimerait vous poser des questions.

Question du public

Monsieur Castells a parlé de ses réseaux. Vous aussi avez parlé de réseaux, de réseaux de chercheurs italiens et français, un réseau social très fort. Vous avez aussi parlé de réseaux à l’époque du Moyen Âge, de la culture des sanctuaires où les individus avaient l’impression de créer un sentiment de bonheur. Vous-même, croyez-vous que dans ces réseaux de chercheurs et dans ceux du Moyen Âge on a créé le sentiment de bonheur?

André Vauchez

C’est une question très difficile, parce qu’il existe des réseaux où les chercheurs sont heureux et d’autres où ils souffrent. En général, les chercheurs sont heureux de travailler en équipe, ce qu’un sociologue a appelé « le bonheur d’être inclus », et la contrepartie du « bonheur d’être inclus » est la « douleur d’être exclus ». Donc, en général, on est content d’être inclus dans un groupe de travail de recherche. Cela dit, il y a des gens avec un tempérament individualiste qui préfèrent travailler tout seuls dans leur coin.

Pour ce qui concerne le Moyen Âge, c’est différent. Les sanctuaires étaient créés de manière spontanée un peu partout. À partir du douzième, treizième siècle, ils commencent à être hiérarchisés. Il y a les très grands couvents en Europe, à Assise, à Saint-Jacques-de-Compostelle, de très grands sanctuaires comme le Mont Saint-Michel qui sont vraiment les plus fréquentés. Au Moyen Âge on donnait parfois comme punition, même justicière, le pèlerinage pour éloigner les mauvais sujets de la société. Nous avons à disposition des listes de pèlerinages infligés par les tribunaux comme sanctions ; là on voit qu’il y a des sanctuaires qui sont en tête des réseaux et
puis il y a de plus petits sanctuaires locaux du village ou du canton où les gens se rendaient pour des raisons de santé, pour la fécondité du bétail... il y a toute sorte d’usage possible. Aux yeux de l’Église en tout cas il existait une hiérarchie entre les grands et les petits sanctuaires. Donc, ceux qui se trouvaient dans un sanctuaire comme punition jouissaient probablement moins du bonheur d’être inclus.

Giorgio Cracco

Aujourd’hui est un jour de gloire non seulement pour la France, mais aussi pour l’historiographie italienne. Et cela grâce à André Vauchez qui a mobilisé l’historiographie italienne surtout sur le thème des sanctuaires. Presque toutes les universités italiennes ont contribué au grand « Censimento » qui a été réalisé.

André Vauchez a écrit un livre vraiment remarquable sur François d’Assise: non seulement sur sa vie, mais aussi sur sa mémoire. Nous avons aujourd’hui un Pape qui s’appelle François. Je voudrais demander à André Vauchez de quel François il s’agit.

André Vauchez

Je dirais que le choix de son nom, une fois qu’il a été élu, est un choix symbolique, un choix significatif. On ne choisit pas un nom comme cela au hasard. On peut s’inscrire dans une continuité en choisissant Pie XII après Pie XI, mais on le fait toujours avec une optique très précise. J’ai tout lieu de penser que si le Pape – nomen est omen – a choisi ce nom, c’est parce qu’il voulait se rattacher à l’idée, ou à l’idéal d’une Eglise pour pauvres et humbles.

Karlheinz Stierle

Si on voulait résumer en une formule le centre de vos intérêts, pourrait-on dire que c’est la spiritualisation du monde et la mondialisation de la spiritualité ?

André Vauchez

Vous me faites plaisir, je n’y avais pas pensé par moi-même, mais pourquoi pas ? Ce que j’ai essayé de faire tout au long de ma carrière comme chercheur c’était de faire descendre la spiritualité, je dirais des « sommets » – sans contester l’importance de grands personnages comme saint Bernard, saint Thomas d’Aquino ou d’autres qui ont tout à fait leur place et qui sont évidemment fondamentaux. Mais je pense que dans le domaine de l’histoire religieuse, jusqu’à il y a une quarantaine d’années, on s’est beaucoup trop concentré sur une histoire sommitale, l’histoire qui marchait sur
les cimes. On parlait du rôle du Pape, du grand abbé, etc., et tout cela concernait une frange extrêmement mince, une élite spirituelle politique et religieuse.

Avec les historiens médiévistes de ma génération – je ne suis pas le seul – nous avons essayé de faire descendre un peu le ciel sur la terre afin de montrer que la spiritualité d’en-bas n’est pas seulement l’apanage d’un groupe restreint, mais aussi l’apanage des moines qui, à partir du XIIe siècle, avaient également de la spiritualité laïque; c’est absolument incontestable, une spiritualité fondée sur l’idée de la charité, sur la bienfaisance, sur la création d’hospices, et puis il y a aussi la spiritualité du pèlerinage.

Le pèlerinage n’est pas seulement une pratique populaire; les grands mystiques des XIVe et XVe siècles ont tous fait un pèlerinage. Il n’y avait pas de contradiction entre pèlerinage et mystique. Donc, il fallait montrer que cette notion de spiritualité ne devait pas être entendue dans un sens restrictif. Il y avait des niveaux, mais il ne fallait pas les distinguer par valeur.

Il y a des lieux sacrés qui ont toujours joué un rôle de polarisation religieux, culturel, mystique qu’aujourd’hui on a du mal à imaginer… à Cluny par exemple, car l’église a été détruite après la révolution française et on peut dire la même chose pour Clairvaux où il y avait un immense monastère de Saint Bernard qui a exercé son rôle sur tout l’Occident. Je crois que les lieux et les hommes sont beaucoup plus liés que ce que l’on a admis jusque-là.

Luciano Maiani

Le concept du sanctuaire n’est pas exclusif du Moyen Âge européen. Il y a dans le monde – je pense au Mexique que je connais un peu et à l’Asie – des lieux que l’on peut classifier comme sanctuaires. On pourrait dire que les hommes sont égaux, mais en comparant les caractéristiques des lieux on pourrait apprendre des choses sur les différentes civilisations.

André Vauchez

Vous avez tout à fait raison. Le mot sanctuaire n’a rien de spécifiquement chrétien au niveau mondial, mais il y a quand même des religions sans sanctuaires… sans toucher le protestantisme dont on pourrait discuter. Je pense à l’Afrique, où il y a des sanctuaires, mais il s’agit de sanctuaires chrétiens. Là où les sanctuaires sont importants on trouve des contextes où il y avait des moines, dans le bouddhisme par exemple et dans la chrétienté médiévale. Donc, la présence d’une vie religieuse monastique favorise la naissance de sanctuaires pour les visiteurs, les pénitents, etc. Je crois toute-
fois que c’est très différent si on voit un sanctuaire aztèque, bengali ou chrétien du Moyen Âge, car il me semble que selon les spécialistes de la religion, précolombienne surtout, ce qui est central dans ces religions c’est le sacrifice. Dans les lieux chrétiens et bouddhistes le sanctuaire n’est pas un lieu de sacrifice.

*Heinz Gutscher*

Je remercie André Vauchez et passe la parole à Thierry Courvoisier, professeur d’astrophysique à Genève et président des quatre académies suisses.
Academic research does not follow a smooth curve. From time to time a ground-breaking discovery or insight is made. Such research often causes major transformations within the field of the researcher and may lead to what Thomas Kuhn referred to as a paradigm shift. In the context of research funding, it is of great importance to understand, if possible, why and how these discoveries and insights occur. Therefore, we would like to pose the following key-questions. Are breakthroughs rather the result of new material or, instead, primarily the result of a rearrangement of material already familiar and present? Do breakthroughs follow a previous pattern of research or do they represent a different form of rupture, discontinuity or sudden change? Are new insights rather the result of a continuous “evolutionary” development, a kind of extension of existing research into new intellectual or practical terrain or do they constitute a sharp break with the past, transforming an entire academic field? Are there any signs which indicate impending ground-breaking research, or to put it the other way round, does something eventually happen that was previously imaginable or are breakthroughs unexpected, or even inconceivable? Are such discoveries or insights always immediately perceived as breakthroughs? Is the perception of breakthroughs subject to an independent set of specific criteria, or is it sometimes constructed by academic networks?

These questions are to be seen in the general frame of seeking the most fruitful environment or environments for high quality research. It is a quest which is very general; you will see funding agencies and academies all over the world pondering what to do so that the people they fund or they collaborate with produce the best and win prizes such as the Balzan. These questions are legitimate in the context of optimizing public funding.

I propose that we proceed in the following way: to ask Madame Cossart and each of these gentlemen prizewinners to individually give their views on these questions, and then we will devote a good half hour to a question and answer session involving the audience. Professor Aspect, might we begin with you?
Alain Aspect

According to my experience, we need a good equilibrium between bottom-up and top-down science. Bottom-up means total freedom; everybody chooses his subject. Of course, intellectually this is a good idea. However, experience shows that people who set programmes, that is the top-down approach, are not total idiots. They often identify interesting subjects. But the top-down approach is at risk to miss ideas coming from creative people. I would therefore advise all the funding agencies, including our hosts, to provide a reasonable equilibrium between programmes with well-identified subjects that people think are important, and a reasonable fraction of what we call in France *programmes blancs*, that is to say, a programme where you come along with any idea and you say, “This is my idea, go evaluate it, and please give me some money for something which is new.” That is the result of my experience.

Thierry Courvoisier

Thank you very much. Professor Castells what do you think?

Manuel Castells

Well, it’s easy to say that it is, in fact, a continuity of breakthroughs, meaning that science really progresses – I agree with Thomas Kuhn – by leaps forward at one particular point, but at the same time, you have to connect the dots between these different breakthroughs, and this can only be done through actual experimental research, or quasi-experimental research in the case of the social sciences.

I would quickly address your second point, dealing with the consequences of these perspectives for research funding. Here I mean, what are the conditions under which we can favour or otherwise scientific breakthroughs? And here my experience is relevant. As some of you know, I was a founding board member of the European Research Council, and there we had a huge battle on funding interdisciplinary research. Of course, I was on the side of interdisciplinary research, but was in a tiny minority, however in a very respectful environment, because ultimately we dedicated between 15% or so of the funds to interdisciplinary research, which is a huge victory given the odds at the beginning. The reason for that is that disciplines are not scientific or epistemological constructions. They are peace treaties after endless wars between scientific bureaucracies and institutions. There is molecular biology; there is micro-cellular biology. They change constantly.
So disciplines defined in strictly disciplinary terms block scientific breakthroughs and block innovation, because they reproduce the powers that are invested in certain specific fields, and this actually starts the war. So I really think not only material conditions are crucial – so are intellectual conditions to allow for experimentation on the margins of defined scientific fields, and therefore grant sufficient funds for that experimental kind of research.

**Thierry Courvoisier**

Thank you very much. Madame Cossart, please.

**Pascale Cossart**

I think it is very important to introduce one discipline into another discipline at the right moment. We have seen that in different areas of biology. For example, I talked about the merging of cell biology and molecular biology. Right now metagenomics is widely used to analyze the intestinal flora, i.e., the intestinal microbiota’s composite – many teams are studying the intestinal flora, and these studies are leading to new discoveries in immunology. These studies also generate a new vision in medicine. So I think at the right moment, if two disciplines merge, it’s very, very possible that there will be breakthroughs.

**Thierry Courvoisier**

And what about the historical perspective, Monsieur Vauchez?

**André Vauchez**

Dato che sinora nessuno ha parlato in italiano, inizierò in italiano.

Nelle scienze umanistiche la situazione è un po’ particolare, ma direi che, con i tempi che corrono, ci sono alcuni grossi problemi che ostacolano lo sviluppo della ricerca. Il primo è ben noto e basta accennarlo perché tutti sappiamo che mancano i fondi, i finanziamenti, ma soprattutto anche i posti. Soprattutto negli ultimi cinque anni il reclutamento di ricercatori negli organismi di ricerca è diminuito molto e c’è tutta una generazione di ricercatori, fra i quali alcuni molto bravi, che è stata ed è tuttora sacrificata. Il solo torto che hanno è di essere nati in un certo periodo e non cinque anni prima. L’altro problema che mi preoccupa un po’ è la cultura della valutazione, l’évaluation. È una bella cosa e l’idea è buona, ma siamo arrivati, mi sembra, almeno nel nostro settore, a una situazione tale che i responsabili di ricerca devono passare un
terzo del loro tempo a scrivere dei rapporti e a spiegare il perché della loro ricerca, elencando i risultati raggiunti, sempre in una prospettiva burocratica-amministrativa.

Anche questa situazione è un freno molto pesante alla ricerca, tanto più che queste ricerche sono valutate, dopo, secondo criteri poco chiari. Ciò crea anche una certa instabilità, una preoccupazione per i ricercatori. Quindi penso che la situazione attuale è preoccupante.

Un altro punto che aggiungerei riguarda soprattutto le scienze umanistiche. Negli ultimi trent’anni abbiamo capito anche noi l’importanza dell’informatica e della creazione dei database e l’enumerazione dei documenti ecc. Abbiamo dato molti passi avanti in questo campo. Solo che adesso ho l’impressione che il fatto di aver costituito questi corpus, questo insieme di documenti numerizzati, finisce per costituire lo scopo della ricerca, mentre in effetti è solo uno strumento per la ricerca: la numerazione dovrebbe rimanere l’aspetto tecnico e ci sono pochi ricercatori che hanno anche la preoccupazione di interpretare parallelamente i risultati forniti dal database.

*Thierry Courvoisier*

Thank you very much, André Vauchez, I think that many intriguing elements have emerged from this discussion. Any further contributions?

*Alberto Quadrio Curzio*

Ho trovato le due osservazioni, quella sugli studi interdisciplinari e quell’altra riguardo alla prevalenza dei criteri di misurazione “meccanizzati”, molto preoccupanti per le scienze umanistiche. Se noi guardiamo il piano finanziario poliennale 2014-2020 dell’Unione europea, scopriamo che su mille miliardi su sette anni, che vuol dire circa 140 miliardi all’anno, 80 miliardi sono destinati alla ricerca. Quindi una cifra piccola. Di questi 80 miliardi, alle scienze umanistiche o agli studi interdisciplinari andrà una piccolissima parte. Credo che questo non sia tanto un problema degli studiosi nelle scienze umanistiche, che all’Accademia Nazionale dei Lincei ancora si chiamano “scienze morali”, ma è un problema della scienza in quanto tale. Sono del parere che se si marginalizzano troppo le scienze morali ne seguiranno anche dei danni alle scienze naturali e matematiche.

Basta leggere il Linceografo scritto da Federico Cesi e corretto da Galileo Galilei per capire l’importanza che questi personaggi davano alle scienze morali. Ho l’impressione che dalla storia traiamo un insegnamento di continue intersezioni tra scienze morali e scienze naturali; ed è l’intersezione che spesso ha generato il progresso.
Penso che come scienziati dovremmo ininterrottamente segnalare agli organi dell’Unione europea l’importanza di mantenere un certo equilibrio e valorizzare le ricerche interdisciplinari.

Thierry Courvoisier

Thank you. Heinz Gutscher, do you want to get in here?

Heinz Gutscher

The question is whether breakthroughs are actually the result of new material. I have an observation. In the Internet, a relatively small sub-world exists – about 10,000,000 people – out of which every month 1,000,000 of them are moving their avatars in their own little virtual world. It’s called Second Life. And I observed that, interestingly enough, in this virtual world, there are banks, products are sold in virtual shops and billions of euros change hands. What I also learned is that there is a kind of sanctuary, indeed churches are there. So would that be possibly interesting material to observe and study the coming into existence of holy places in the virtual Internet world? It’s a strange world and I would be interested, for instance, if you, Professor Castells, would say that this is insignificant.

Manuel Castells

It’s being done. There are already to my knowledge about 100 doctoral dissertations on Second Life completed, and there are many, many dissertations on this point and hundreds on the religious life on the Internet, and the presence of different religions and how they interact and on spirituality in Second Life. This is a very important phenomenon, and as I mentioned, there are thousands of Internet researchers in the world, and thousands of doctoral students picking up on all these phenomena.

Thierry Courvoisier

Professor Padoa Schioppa, please.

Antonio Padoa Schioppa

André Vauchez a récemment écrit un livre magnifique sur saint François qui peut être lu et apprécié aussi bien par des lecteurs qui ne sont pas des historiens de métier, que par des spécialistes qui comprennent aisément que derrière chaque mot il y a toute une doctrine.
Je pose donc une question aux collègues scientifiques, mais qui concerne aussi les sciences humaines : comment pourrait-on favoriser une divulgation de qualité – donc proposée par quelqu’un de qualifié – qui favorise d’une part des vocations scientifiques parmi les jeunes et d’autre part la dimension fondamentale de l’interdisciplinarité, ce qui implique que des chercheurs spécialistes de domaines différents puissent la comprendre de manière suffisamment précise ?

Et encore. On peut recueillir sur internet une quantité énorme d’informations : comment peut-on être aidé à distinguer les contributions sérieuses des synthèses superficielles qui sont parfois au premier plan dans Google ?

Alain Aspect

I am invited to answer in English. So I will limit my reply to the question of popularization. I have some experience concerning this, and I think there are two possibilities: one which is easier, indeed the easiest, is to talk to a very good journalist. By a very good journalist, I mean intelligent and modest. I had an excellent example decades ago with the French journalist François de Closets. He was a real star, and at that time I did not receive prizes like the Balzan Prize, I was a small guy. Nevertheless, he came to me saying, “I don’t know your field. You are going to explain it to me until the point I can regurgitate it to you and you agree that I have reasonably well understood the concepts. Then I will write a paper for the public.” This was great. It produced a very good popularization. The second option is that the scientist makes the effort to write the popularization himself/herself, trying to put himself in the frame of mind of the general public and of colleagues in different fields.

An example, in quantum information, would be the book of Nicolas Gisin. He has enough experience, and with this experience I think he found a way to put himself in the position of the public. On the other hand, I think that all professional scientists can find something interesting in his book. So I suppose it matches your last request.

Thierry Courvoisier

Mme Cossart, please?

Pascale Cossart

I can just add, to reinforce what Alain has said, that there is a journalist in the French radio Marie-Odile Monchicourt who was first conversing with you, and then when we were recording the programme, she would say, “I’m going to ask a few ques-
tions”. She had a very limited time, three minutes, but her questions were very good, because she really knew what she was asking. So that’s one possibility.

Another possibility is that you might be invited to give a talk at a conference whose theme is not really in your field. For example, one day I was invited to a chemistry conference, and people were fascinated, maybe because biology was easy to understand, but… so I think, there should be also an effort from us. We have to make the effort to explain to people who are not from our field.

Thierry Courvoisier

I think it’s true. I think this cross-talk is something which cross-fertilizes an awful lot, and I think we should probably invite colleagues to our conferences and accept invitations when they come from other fields, but that’s rather seldom.

Question from the audience

I have a question for Professor Castells. During your brilliant presentation on the value and the progress of networks in our society, you made the statement that there are hard facts which are really showing that sociability and autonomy are enhanced. May I ask you are these really – is this measured using criteria which are going beyond superficial contact and so on, and what is your view of the value of very early and intense Internet interaction in early childhood?

Manuel Castells

Thank you. Well, first of all, what I mentioned here in the paper, is that these are observations from a number of very good sources, which are scholarly sources – not media sources, not company sources – but scholarly sources. There are many, many studies on the social effects of Internet, on sociability, on culture, on media, on education. So we have a body of Internet studies.

In my personal case, besides the contact with all these different institutes and data sources, I had the possibility between 2002 and 2008 to scan entirely a complete society – Catalonia – with a mega study, an empirical study on all the dimensions of the Internet in this society – 55,000 interviews, of which 15,000 were face-to-face. A summary of the information, including sociability, political processes, etc., is there. Now, in terms of what is the importance of the Internet for researchers, I think it’s fundamental. It’s through the Internet that we interact, we communicate, we constantly exchange papers, ideas, information. We scan whatever is published or is in the process of being developed. And moreover, the scientists are those who actually can
retrieve more reliable information from the wealth of information on the Internet because we know, we understand. The problem of the Internet, with lots of information is not so much that there’s so much information, but rather that most people don’t have the education and cultural capability to discriminate when accessing the information. If I go to the Barcelona library and I have one million volumes, and I go to the Berkeley library, and I have twelve million volumes, I’m not going to read one million, or twelve million! But I will have greater chances of finding what I need in the twelve million-volume library than in the one million-volume library. I need, however, to know what I’m looking for! And to apply criteria that relate to the kind of research that I want to pursue, the kind of theory that I want to build, and ultimately use the information for knowledge. That’s the critical thing. Gathering knowledge with knowledge.

_Thierry Courvoisier_

Don’t you have a slight worry with that sort of approach – that actually everybody’s going to do the same thing? So we have a sort of bandwagon effect that comes along, and somehow we might lose a bit of originality, which is something that one needs for breakthroughs, isn’t it?

_Manuel Castells_

Well, now we have the same thing that happened when the printing press was invented. The church in particular panicked about the possibility of holy books being distributed. People would have their own interpretation, and there were wars for years and years exactly about that. Books were being burned. Well, we are in the same situation. Any epoch in which technology diffuses and popularizes the access to information and ideas for people at large, the elite try to control that. But the genie’s out of the bottle.

_Thierry Courvoisier_

Madame Schwegman, please?

_Marjan Schwegman_

Thank you. I have a question about the role of the new digital technology in producing scientific breakthroughs. Is it just providing auxiliary instruments? Does it facilitate good research, or does it produce in itself a breakthrough? In the Dutch
Academy of Arts and Sciences, a big discussion is on – and I think not only there – about the role of digital technology in the humanities. And if I limit myself to the discipline of history, it is said that it is not only very good for our research that many sources are being digitized, but that the development of advanced digital tools will eventually change the nature of our discipline in the sense that now historians will be able to discover the laws of history, and they will be able to discover patterns that are liberated from the bias of the individual historians, and so that eventually historians will be able to predict the future. I think that will be really a breakthrough and a revolution, and I’m very curious what the panel thinks about that.

Thierry Courvoisier

Who wants to start on that question? I think, Monsieur Vauchez, you’re condemned to do so. Please.

André Vauchez

Come dicevo prima, i progressi della digitazione e della numerizzazione sono un fatto veramente positivo e indiscutibile. Ciò ci consente di arrivare a dei dati a cui non si poteva sperare cinquanta anni fa. Quindi in questo senso non c’è niente da dire e non c’è niente contro il processo in corso. Comunque, per fare una buona digitazione e numerizzazione bisogna porsi dei criteri scientifici. Non basta accumulare dei dati e mettere assieme agenti di origine non precisata in una sorta di calderone. La preparazione è necessaria. La fase tecnica è interessante e importante, ma è il lavoro preparatorio che è fondamentale. Con un gruppo di ricerca venti anni fa mi sono occupato della costituzione di un database su tutte le lettere dei Papi del Medioevo: sono decine di migliaia a partire dal tredicesimo secolo… e più si va avanti nei secoli, più sono numerose. Per realizzare due CD rom – fra poco esce il terzo – ci sono voluti cinque anni di preparazione. Ciò per mettere a disposizione un metodo sicuro che prenda atto e non trascuri le esigenze che risultavano dallo stesso documento, cioè di non mischiare i tipi di lettere che non avevano niente in comune. Perciò, sono cento per cento per la digitazione e la numerizzazione, ma a patto che ci sia la massima cautela nella fase preparatoria che richiede grandissime conoscenze del campo.

Manuel Castells

Well, I can also comment on this problem if you want some personal experience. I am currently in the Scholars’ Council of the largest library in the world, the US Library of Congress, with 180,000,000 items, and they are in the very advanced process
of digitizing all that information, and they’re absolutely excited about it because they’ve always said, “We are the library of the people! We are not the library of the historians who come to check on old manuscripts.” So they have a deep democratic feeling that finally they are going to be able to present an opportunity to access this huge library – the Library of Alexandria of our time – by anybody! However, at the same time, you don’t access the library just like that. You need some librarians’ advice. You need a number of people that can help with where to retrieve what and how to relate to other things. To deal with that, there are two things. One, very sophisticated software that is in the process of being installed that uses the semantic web. The semantic web, as you know, is not something that can be properly accessed by just simply typing a word – it’s a whole context that is being created automatically, and that’s essential. And second, they don’t have the personnel to manage this incredible desire of access to information because they are suffering drastic cuts, as many other cultural institutions. Now, they’re trying to compensate for that by creating networks of scholars who do voluntary work in different disciplines, and work as advisors for these thousands and thousands of people who want access, but they don’t know how. And I think it’s a very novel attitude for historians and for scientists to help.

In terms of the diffusion of knowledge, that’s a key – how to teach people, to show them how to access the sources of information. That, in my opinion, is an obligation for scholars.

*Thierry Courvoisier*

Thank you. Please, one more question?

*Question from the audience*

Professor Castells, you’re a proponent of interdisciplinary research, and did you have the possibility to cooperate, for example, with urban developers and architects more precisely? I am asking you because fourteen years ago – it was 1999 – I had a conversation with a professor of the Berlage Institute, a graduate architectural school in the Netherlands, and he told me at that time that when one came to a square, to a public place in the city, and half of the people who were there were actually not there because they were interacting with mobile phones – and with computers as well. They were not just reading books passively. They were interactive, they were simply in another *universum*. So I think that digital technology has not only influenced the private sphere, or the business or intellectual sphere in the scientific community but also on a more practical level… in daily life, like people in the public space.
Manuel Castells

Well, you know, to make a long answer short, I can refer you to the work – absolutely pioneering work – by the late William Mitchell, the former Dean of Architecture at MIT, who wrote a number of books based on his observations and studies – City of Bits, e-topia, etc. – in which he shows that there’s in fact a new type of public space that’s being created, which is a combination of both: the network space and the physical space, the interactive space. And many architects have designed that, for instance, in public squares in a number of cities, to have multiple hotpoint connections. And guess what? People are connected there. But in order to be connected they have to be there, and at the same time, they can be sipping some little coffee or smoking something. They can actually be more stimulated by doing this together than in the isolation of their homes. We are in an electronically networked society and the idea is then to combine different forms of the space in what Bill Mitchell called e-topia.

Thierry Courvoisier

One more question from the audience, please?

Yan de Kerorguen

Je voulais juste intervenir en tant que journaliste sur une question qui avait été évoquée dans la séance des sciences pour simplement dire que la notion de journaliste a, selon moi, un peu perdu de son sens avec les nouvelles technologies, avec internet. Impossible de faire un prix de gros sur la compétence/non compétence des journalistes.

Beaucoup de gens deviennent experts, beaucoup de journalistes aussi perdent leur expertise. De la même façon qu’il y a de nouvelles disciplines en sciences, il y a dans les études de journalisme plusieurs métiers. Dans la presse écrite, quand on écrit dans un magazine ce n’est pas la même chose que d’écrire dans un quotidien, travailler à la radio, animer une émission à la TV. La question du temps de traitement médiatique est également importante. Il faut parfois aller vite pour « boucler ». Il n’est pas le même dans un quotidien et dans un mensuel. Si on veut aller au plus profond de la question de la popularisation, « comment faire comprendre la science et comment faire envie aux jeunes de faire de la science », la chose à trouver est, je crois, dans le dialogue. Il faudrait se poser dans un rapport de mutualisation commune, dans un dialogue citoyen entre le scientifique et le journaliste pour arriver à un langage commun et se comprendre. Si les journalistes doivent s’efforcer de clarifier le message scientifique
pour leurs lecteurs/auditeurs, les scientifiques doivent aussi intégrer les conditions particulières de l’opération journalistique et réaliser que l’écriture médiatique procède forcément d’un tri, d’une interprétation et d’un style et que ce travail est fait pour un lecteur/auditeur.

*Thierry Courvoisier*

Thank you. You are right. What you said is something that we have seen over the years, and that our interactions with journalists get to be shorter in time, and the quality of what comes out suffers a bit from that.

*Alain Aspect*

From this point of view, there is something which is a complete disaster. It is the press bureau of big universities, which also work with more and more urgency, in the short term, and quite often, they twist the arm of the scientist in order to publish. They have the tendency to want to publish too fast. I mean, it’s not only the newspapers’ fault. It’s also press offices of big institutions, and we should be aware of it and oppose it as far as we can.

*Thierry Courvoisier*

Thank you very much. I think this warning is something we should really be well aware of in many cases and in general in all science and culture. I would like to call now on Salvatore Veca to close this session and to distillate the *substantifique moelle* from all what has been said this afternoon.
Conclusion

Salvatore Veca

Merci, Thierry Courvoisier, je vais donc tenter d’esquisser quelques conclusions de ce vaste programme.

Je voudrais avant tout remercier – avec gratitude – tous nos amis et collègues suisses pour avoir organisé si remarquablement le forum interdisciplinaire d’aujourd’hui qui – je vous le rappelle – est le troisième qui se tient ici en Suisse. Il s’agit d’une petite tradition que je considère vraiment importante à la lumière aussi de ce qui a été mentionné lors du panel conclusif.

Plus particulièrement je remercie Daniel Höchli, Directeur du Fonds National Suisse qui nous a accueillis, Thierry Courvoisier, Heinz Gutscher, Peter Meier-Abt et Markus Zürcher, qui ont animé cette rencontre et contribué à son succès.

Bien entendu, mes remerciements vont également aux collègues du Comité Général du Prix qui, cette année encore, ont magnifiquement travaillé pour arriver à des choix excellents comme vous avez pu le constater vous-mêmes aujourd’hui ici dans les deux sessions humanistique et scientifique ainsi que dans le panel de conclusion: les lauréats Balzan – auxquels vont mes félicitations – sont la grande source du prestige et de la réputation de la fondation.

J’aimerais aussi remercier quelqu’un qui n’est pas parmi nous cette année, j’ai nommé Bruno Bottai qui n’a jamais manqué de souligner le caractère italo-suissé de la Fondation Balzan et qui, avec mon collègue Alberto Quadrio Curzio – que je remercie également – a proposé et lancé cette initiative, en promouvant et en soutenant les conventions entre la Fondation Balzan d’une part et les Académies suisses des Sciences et l’Accademia Nazionale dei Lincei d’autre part.

Nous avons eu un panel très intéressant avec l’intrication de nombreux thèmes. J’ai eu l’impression – et ceci me semble très intéressant sur le plan intellectuel – que l’intrication a eu lieu dès le début de la première session du forum avec la présentation de la part de Pascale Cossart de son travail de recherche sur les aventures de Listeria, puis avec celle d’Alain Aspect qui nous a montré la dimension épistémologique de la science en présence d’une convergence des champs scientifiques, mais aussi d’une divergence sur les interprétations ; c’est dans de telles circonstances que peut s’ouvrir un nouveau domaine de recherche. Ainsi c’est un ensemble de thèmes qui nous ont été proposés, où les ruptures, les ouvertures d’horizons, les projections les plus audacieuses dans les sciences, dans la connaissance, ne découlent que de tensions, de difficultés, de situations dans lesquelles il y a des chemins que
l’on ne peut pas parcourir. Mais ce sont ces limites qui mènent à des possibilités d’explorer en ouvrant un nouvel horizon intellectuel. Le thème que j’ai déjà entrevu dans ces sessions et que j’ai retrouvé dans le panel est le thème récurrent de l’interaction des disciplines. J’ai été frappé par votre expression, Madame Cossart, quand vous avez dit « il faut trouver le moment juste dans lequel une discipline est introduite dans une autre ». Le problème est de trouver le moment juste. Le problème est de trouver les conditions qui font que le moment est juste ; il s’agit d’une exigence pour la discipline qui est introduite dans l’autre pour préserver sa vocation de recherche, pour pouvoir atteindre son propre but. Le croisement des disciplines et le changement même des disciplines ne dépendent pas de la méthode, ni d’un critère, pas même d’un ensemble de critères. Il n’existe pas de critère pouvant changer les disciplines mêmes ; c’est le but qui reste, le but fondamental de la connaissance dans tous les domaines des sciences.

Enfin, le thème qui a croisé tous les thèmes est celui de la variété des effets, des vertus et des vices que les technologies qui sont à notre disposition ont dans le domaine de notre recherche. Ce thème s’est croisé avec la question de la divulgation qui est au cœur du dialogue entre le Fonds national suisse pour la recherche – où nous nous trouvons – et le public, et le public plus large, la société, et les acteurs politiques. L’acteur politique est celui qui, dans nos sessions, a été évoqué et critiqué. Au moment de la très grande faiblesses de la politique par rapport à d’autres types de pouvoirs sociaux, globalisés, nous avons besoin d’ouvrir, de maintenir et de préserver les conditions du dialogue avec la polis. Mais la possibilité du dialogue présuppose que l’on définisse les conditions du dialogue et présuppose qu’il y ait divulgation du dialogue. La divulgation ne peut pas être sous-estimée. Je me trouve dans la situation de dire que l’un ou l’autre parmi nous sera heureux de faire partie d’une entreprise collective comme celle de la Fondation Balzan qui crée et ne cesse de promouvoir le dialogue. Un grand merci à vous tous qui avez participé aujourd’hui à ce Forum : au revoir et à la prochaine édition.

Auf Wiederschauen und bis zum nächsten Mal.
The 2013 Prizewinners’ Research Projects
Alain Aspect, Professor at the Institut d’Optique Graduate School and the École Polytechnique, Palaiseau; CNRS distinguished scientist emeritus at Laboratoire Charles Fabry, Institut d’Optique, was awarded the 2013 Balzan Prize for Quantum Information Processing and Communication for his pioneering experiments which led to a striking confirmation of Quantum Mechanics as opposed to local hidden-variable theories. His work opened the way to the experimental control of entangled quantum states, the essential element of Quantum Information Processing.

Quantum Information Processing and Communication: Quantum Information with Photons and Atoms

I. “Young Atom Informaticians” conference

The first proposal is to promote a series of conferences, Young Quantum Informaticians, based on the model of the Young Atom Opticians conference launched by Professor Aspect and Professor Mlynek twenty years ago to enable PhD students and postdoctoral scholars working in cold atoms to gain experience organizing conferences, and creating a European community. The structure of the proposed Balzan conference in the domain of quantum information will follow the same procedures: everything must be organized by junior scholars, and senior academics will be strictly forbidden from interfering with the management of the workshop. Funds will be made available after their project is approved by an ad-hoc committee composed of international experts (Philippe Grangier, Nicolas Gisin, Jürgen Mlynek, Peter Zoller).

II. Quantum Simulations of Correlated Matter with Ultra-cold Atoms

The second proposal is to fund two young researchers, David Clément and Marc Cheneau, in a joint project involving quantum simulation of correlated matter with ultra-cold atoms. They intend to take sophisticated measurements giving access to quantum properties of entangled many-body systems of condensed matter. Marc Cheneau’s project concerns a cold atom quantum simulator of supersolids, and he intends to measure directly spatial correlations with resolution enabling him to see each individual atom. Balzan funding will be used for the acquisition of a high performance camera and the high grade optical components necessary for this goal. David Clément’s project concerns a quantum simulator of a strongly interacting quantum liquid, and he intends to measure how quantum depletion depends on the strength of the interactions. Balzan funds will allow him to buy a laser and to fund a postdoctoral researcher for one year.
Manuel Castells, University Professor and Wallis Annenberg Chair of Communication Technology and Society at the University of Southern California, Los Angeles; Professor at the Open University of Catalonia, Barcelona; Director of Research in the Department of Sociology, University of Cambridge, and Professor Emeritus of Sociology and of City and Regional Planning at the University of California at Berkeley, was awarded the 2013 Balzan Prize for Sociology for his wide-ranging and imaginative thinking through of the implications of the great technological changes of our time: the digital revolution and the profound social and political challenges brought about by the emerging technologies of communication and information processing associated with computing, microelectronics and the Internet. And for having proposed a general theory of the new global information society that has arisen out of these technologies.

The Cultural and Social Dimensions of the Economic Crisis 2008-2014
Financial Cultures, Human Suffering, and Social Protests.

This Project will integrate the results of three sub-projects conducted by young researchers during three years in three different institutions under the supervision of Professor Castells and Professors in these institutions.

Sub-Project 1: Financial Cultures in the US Financial Crisis of 2008-2014. From Wall Street to Silicon Valley
University of Southern California, Annenberg School of Communication Research Group on Financial Cultures

The Research Group on Financial Cultures, led by research fellow Lana Swartz under the supervision of Professors Manuel Castells and Sarah Banet-Weiser at the University of Southern California’s Annenberg School for Communication and Journalism, will study the interconnection of what is often thought of as “cultural” or “financial”. In particular, the objective of the research group is to produce an empirical analysis of the ethical, political, social and technological forms that anticipated and partly induced the 2008 global financial crisis as well as those that emerged in its aftermath. The research will be divided into two sub-projects: Wall Street Financial Cultures and New Economical Cultures emerging in the technology world in entrepreneurial Silicon Valley, such as Bitcoin.
Sub-Project 2: The Cultural and Social Dimensions of the 2008-2014 Economic Crisis: Human and Social Costs of the Crisis. Proposal for a Comparative Study of Greece, Italy and the UK
Department of Sociology, University of Cambridge

This project, supervised by Professors Manuel Castells and John Thompson (Department of Sociology) will explore the ways in which individuals and groups in different parts of Europe live through and experience the economic crisis, how it affects them and how they respond to it, both at the level of feelings, emotions and forms of suffering, and in terms of practices and types of collective action. A bottom-up approach will be adopted in a close, ethnographic study of the daily lives of ordinary individuals in carefully selected regions of Europe, with the aim of developing the concepts we need to understand these feelings, emotions, forms of suffering and practices. It will examine the ways that these responses may feed into types of collective action, including protest movements and other kinds of political mobilization.

Research Group on Communication and Civil Society, Internet Interdisciplinary Institute, Open University of Catalonia, Barcelona

This project is concerned with the dynamics of the current global wave of mobilizations that are shaped and shaping social transformations, and aims to conduct an in-depth, double level analysis of two selected networked movements, 15M in Spain and Occupy Wall Street in the US, with an eye towards comparing the two different experiences in terms of their particular qualities as well as in the context of their dynamics and evolution from an international perspective. The study, supervised by Professor Manuel Castells and Dr Mireia Fernandez-Ardevol, will use innovative quantitative methodology by examining thousands of twits and messages in other social networks, and identifying emotional patterns as sources of social mobilization. The study will also qualitatively analyze the interaction between networked social movements and the political system, studying elections and the new political actors emerging from the movements.

The overall project will lead to several publications by young researchers, as well as to a volume integrating the findings of the three sub-projects, also co-authored by young researchers.
Pascale Cossart, Director of the Unité des Interactions Bactéries-Cellules and Professor de Classe Exceptionnelle at the Institut Pasteur, Paris, was awarded the 2013 Balzan Prize for Infectious Diseases: Basic and Clinical Aspects, for her seminal discoveries on the molecular biology of pathogenic bacteria and their interaction with host cells. Her research has provided very significant insights into the mechanisms underlying infectious diseases and how they might be combated.

Epigenetics and Bacterial Infections: The Role of a Novel Histone Deacetylase SIRT2

This project will further investigate recent results obtained in epigenetics and bacterial infections, a new research area in infection biology. In order to establish a successful infection, bacteria manipulate the host chromatin structure, dynamics and function to their own profit. Bacterial pathogens can manipulate chromatin directly by addressing factors that interact with histones or other chromatin components to the nucleus, or indirectly by interacting with signaling pathways which then affect the chromatin structure or dynamics. Our research has recently shown that the bacterial pathogen \textit{Listeria monocytogenes} infection induces the nuclear translocation of SIRT2, an event dependent on the interaction between the bacterial protein InlB and its receptor Met on the cell surface and critical for a successful infection \textit{in vivo} as shown by the resistance to infection of SIRT2-/- mice.

A graduate student and a post-doctoral fellow will carry out the project, which has four aims: to elucidate the mechanism underlying SIRT2 nuclear translocation induced by \textit{L. monocytogenes} infection; to investigate the genome-wide impact of SIRT2-induced H3K18 deacetylation during infection with \textit{L. monocytogenes}; to determine whether H3K18 deacetylation by SIRT2 is a common strategy used by other pathogens for host subversion; to determine whether \textit{L. monocytogenes} infection induces an epigenetic memory in the host.
André Vauchez, Professor Emeritus at the University Paris Ouest Nanterre, was awarded the 2013 Balzan Prize for Medieval History for his groundbreaking studies on medieval spirituality in Western Christianity and its central role in everyday life in the Middle Ages, for his research on the medieval conception of holiness and on the sacralization of space and time, for his contributions to research on monastic and women’s piety, for his all-encompassing knowledge and masterly presentation of the life, work and influence of St. Francis of Assisi.

The Cult of Saints in the West in the Latter Centuries of the Middle Ages. Research on Shrines and Religious Life in France and Italy

Under the overall theme of The Cult of Saints in the West in the Latter Centuries of the Middle Ages, Professor Vauchez plans to conduct research on two saints in Italian libraries and archives. With the collaboration of a number of post-doctoral students, a number of works on the process of medieval canonization will be published for the first time, as will translations of medieval French texts concerning saints, visionaries and prophets or prophetesses of the time.

Three more projects are planned for Research on Shrines and Religious Life in France and Italy. The first will the complete an inventory of French shrines and places of pilgrimage launched in 1997. A research group comprised of academics, curators and young researchers, historians, art historians and archaeologists and specialists from various historical periods will utilize various perspectives to reconstruct the history of each site. The research will be directed by André Vauchez and Catherine Vincent from the University of Paris Ouest Nanterre. The second, the “Prealp” programme (research on saint murals in the alpine regions) is currently directed by André Vauchez’s former student Dominique Rigaux of the University of Grenoble. International in character, it will encompass all countries of the southern Alpine region (France, Switzerland, Italy and Slovenia), combining field research with the investigation of relevant archives. Three young academics, two pursuing Master’s programmes (in history and art history) and a post-doctoral student in medieval history, will be employed. The third project involves in-depth investigation into the Sabine territory and the region of Rieti, with a research programme that will employ two young researchers, one in religious history and another in art history, to conduct a thorough analysis of the links between shrines and sacred places over the centuries. This work is based on initiatives taken by Vauchez when he was director of the École française de Rome (Lo spazio del santuario. Un osservatore per la storia di Roma e
del Lazio, 2008, and Santuari d’Italia. Lazio, 2010, published in the series “Censimento dei santuari cristiani d’Italia”), which is the basis of the research programme Esperienze religiose, luoghi sacri e storia del territorio in Sabina e nel Reatino directed by Sofia Boesch Gajano (Università di Roma Tre) and Umberto Longo (Università di Roma La Sapienza).
Profiles

The International Balzan Foundation

The *International Balzan Foundation “Prize”* aims to promote, throughout the world, culture, science, and the most meritorious initiatives in the cause of humanity, peace and fraternity among peoples, regardless of nationality, race or creed. This aim is attained through the annual award of prizes in two general academic categories: literature, the moral sciences and the arts; medicine and the physical, mathematical and natural sciences. Specific subjects for the awarding of Prizes are chosen on an annual basis.

Nominations for these prizes are received at the Foundation’s request from the world’s leading academic institutions. Candidates are selected by the *General Prize Committee*, composed of eminent European scholars and scientists. Prizewinners must allocate half of the Prize to research work, preferably involving young researchers.

At intervals of not less than three years, the Balzan Foundation also awards a prize of varying amounts for Humanity, Peace and Fraternity among Peoples.

The International Balzan Foundation “Prize” attains its financial means from the *International Balzan Foundation “Fund”* which administers Eugenio Balzan’s estate.

The Accademia Nazionale dei Lincei

The *Accademia Nazionale dei Lincei*, founded in 1603 by the Roman-Umbrian aristocrat Federico Cesi and three other young scholars, Anastasio De Filiis, Johannes Eck and Francesco Stelluti, is the oldest scientific academy in the world. It promotes academic excellence through its Fellows, whose earliest members included, among many other renowned names, Galileo Galilei.

The Academy’s mission is “to promote, coordinate, integrate and disseminate scientific knowledge in its highest expressions in the context of cultural unity and universality”.

The activities of the Academy are carried out according to two guiding principles that complement one another: to enrich academic knowledge and to disseminate the fruits of this. To this end, the Accademia Nazionale dei Lincei organises national and international conferences, meetings and seminars and encourages academic cooperation and exchange between scientists and scholars at the national and international level. The Academy promotes research activities and missions, confers awards and
grants, publishes the reports of its own sessions and the notes and records presented therein, as well as the proceedings of its own conferences, meetings and seminars.

The Academy further provides – either upon request or on its own initiative – advice to public institutions and when appropriate drafts relevant reports. Since 1992, the Academy has served as an official adviser to the President of the Italian Republic in relation to scholarly and scientific matters.

**The Swiss Academies of Arts and Sciences**

The Association of the *Swiss Academies of Arts and Sciences* includes the Swiss Academy of Sciences (SCNAT), the Swiss Academy of Humanities and Social Sciences (SAHS), the Swiss Academy of Medical Sciences (SAMS) and the Swiss Academy of Engineering Sciences (SATW), as well as the two Centres for Excellence TA-SWISS and Science et Cité. Their collaboration is focused on methods of anticipating future trends, ethics and the dialogue between science, the arts and society. It is the aim of the *Swiss Academies of Arts and Sciences* to develop an equal dialogue between academia and society and to advise Government on scientifically based, socially relevant questions. The academies stand for an open and pluralistic understanding of science and the arts. Over the long-term, they mutually commit to resolving interdisciplinary questions in the following fields:

- They offer knowledge and expertise in relation to socially relevant subjects in the fields of Education, Research and Technology.
- They adhere to the concept of ethically-based responsibility in gaining and applying scientific and humanistic knowledge.
- They build bridges between Academia, Government and Society.
Agreements on Collaboration between the International Balzan Foundation “Prize”, the Accademia Nazionale dei Lincei and the Swiss Academies of Arts and Sciences

(Hereafter referred to as the ‘Balzan’, the ‘Lincei’ and the ‘Swiss Academies’, respectively)

The main points of the agreements between the Balzan, the Swiss Academies and the Lincei are the following:

1) The promotion of the Balzan Prize and the presentation of the Prizewinners through the academies’ channels of communication, in Italy and Switzerland as well as abroad. By virtue of the relations of the Swiss Academies and the Lincei with academies of other countries and with international academic organizations, they will contribute to more widespread circulation of news related to the Balzan;

2) On the occasion of the Awards ceremony of the Balzan Prize, held on alternating years in Berne and Rome, each academy will contribute to the academic organization of an interdisciplinary Forum, in the course of which the Prizewinners of that year will present their academic work and discuss it with other academics proposed by the academies. Furthermore, in the years when the ceremony is held in Rome, one of the Prizewinners will give the Balzan Annual Lecture in Switzerland, and when the ceremony is held in Berne, the Balzan Annual Lecture will be organized at the headquarters of the Lincei in Rome;

3) The academies will contribute to a series of publications in English (ideally with summaries in Italian, German and French), created by the Balzan, with the collaboration of the Balzan Prizewinners.

To promote and supervise all these initiatives, two Commissions have been set up, one between the Balzan and the Swiss Academies (composed of its President, originally Professor René Dändliker, followed by Professor Peter Suter, then Heinz Gutschcher and now Thierry Courvoisier, Dr. Markus Zürcher and Professor Meier-Abt) and another between the Balzan and the Lincei (composed of Professors Sergio Carrà, Lellia Cracco Ruggini and originally Claudio Leonardi†, followed by Carlo Ossola). Both commissions are chaired by Professor Alberto Quadrio Curzio as a representative of the Balzan, which is also represented by Professors Enrico Decleva and Paolo Matthiae, while the Balzan Secretary General, Dr. Suzanne Werder, has been appointed Secretary of both Commissions.
2013 Balzan Prizewinners Interdisciplinary Forum. Above, from left: Marjan Schwegman and Gottfried Scholz, members of the Balzan General Prize Committee. Below: Chairman of the Balzan General Prize Committee Salvatore Veca concluding the 2013 Balzan Prizewinners Interdisciplinary Forum.