



# Panel discussion

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Moderated by

Jean-Pierre BOURGUIGNON, *CNRS-IHÉS*



## Topics to be discussed

- How mathematicians learn and teach;
- How mathematicians do mathematics, communicate it, and publish it;
- How mathematicians interact with the « outer world » about their discipline;
- How mathematicians deal with new trends like big data, etc.

# How mathematicians learn and teach

## Introduction by Ari LAPTEV

# How mathematicians learn and teach

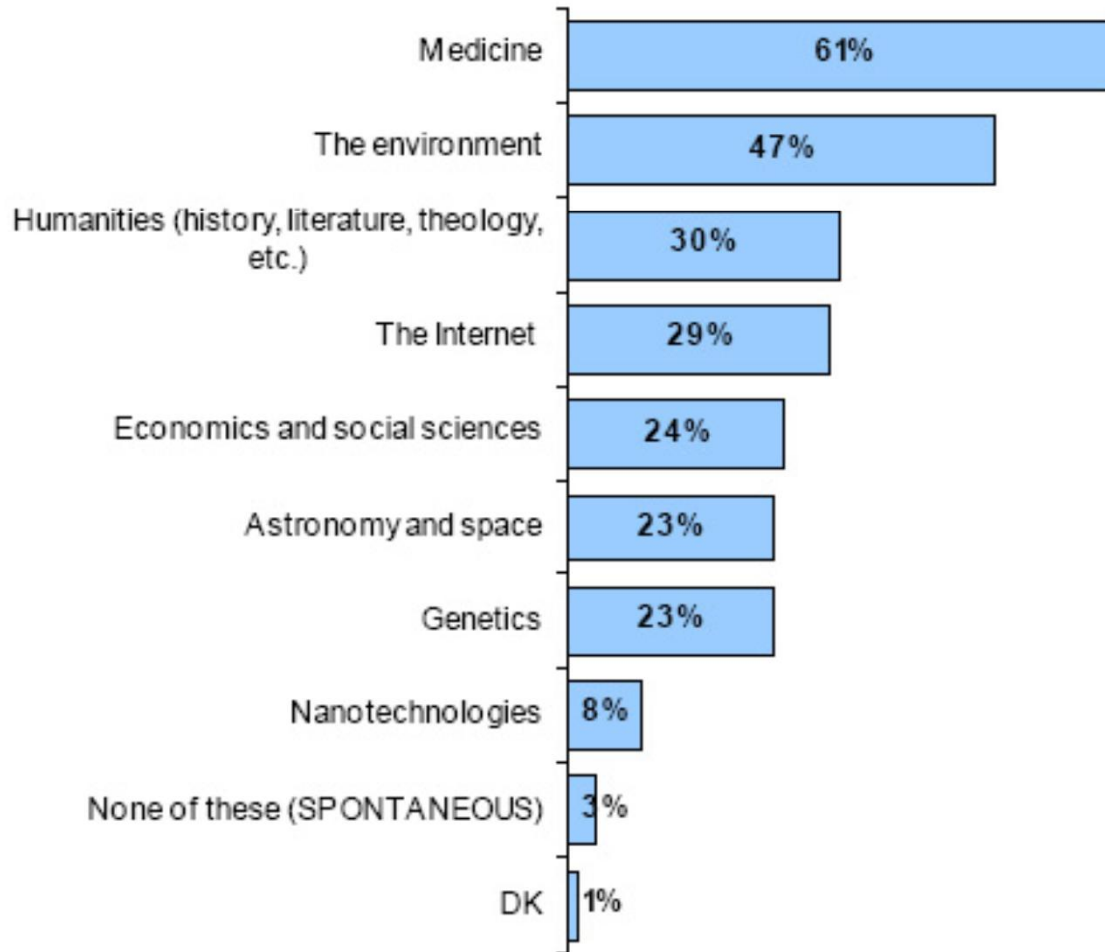
## Introduction by Ari LAPTEV

### General discussion

# How mathematicians do mathematics, communicate it, and publish it

Introduction by Roberto NATALINI

IF VERY OR MODERATELY INTERESTED IN 'NEW INVENTIONS AND TECHNOLOGIES' OR 'SCIENTIFIC DISCOVERIES':  
Which science and technology developments are you most interested in? %EU 25



IF NOT AT ALL INTERESTED IN 'NEW INVENTIONS AND TECHNOLOGIES' AND 'SCIENTIFIC DISCOVERIES' OR 'DK' :  
Why you are not particularly interested in science and technology? %EU 25

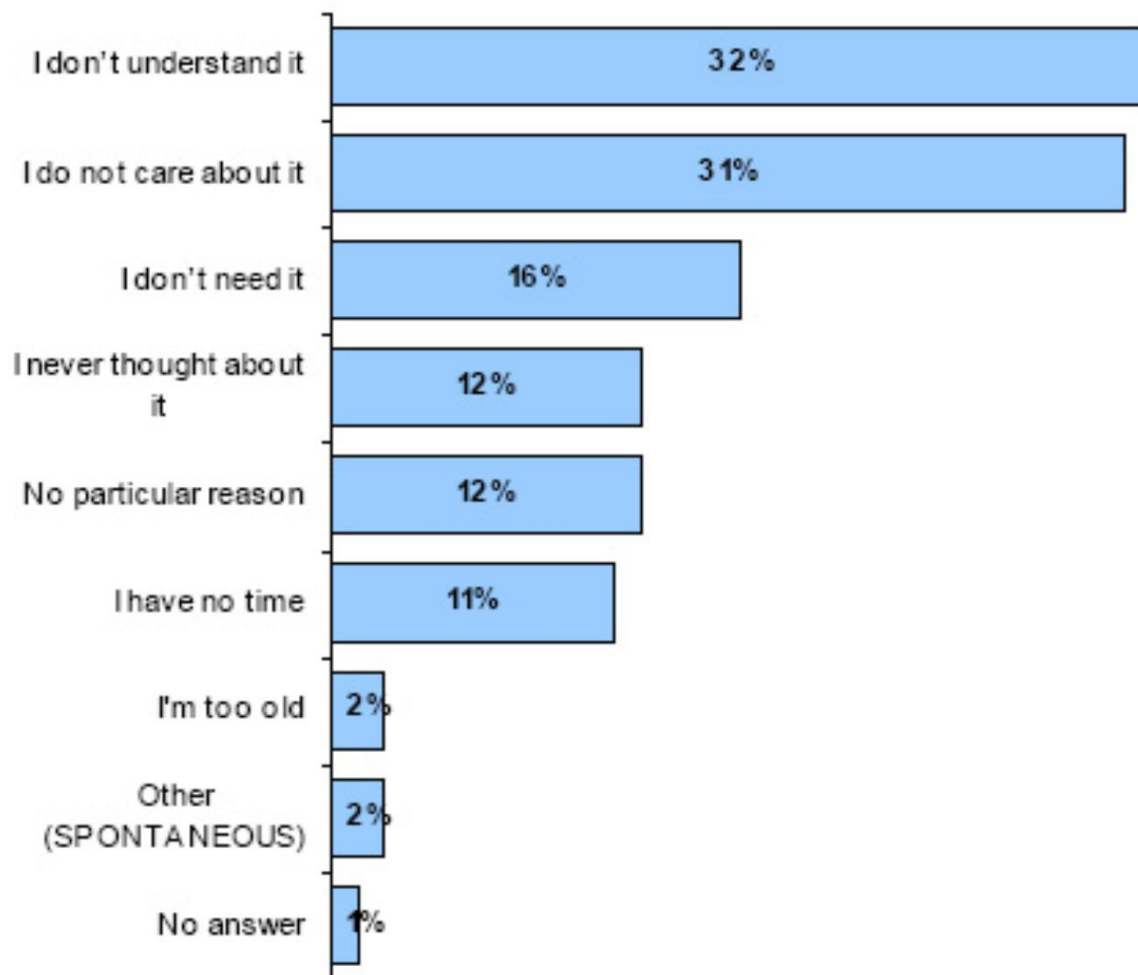




Figure 7-3  
**Primary source of information about specific scientific issues: 2001, 2004, and 2006**

Percent

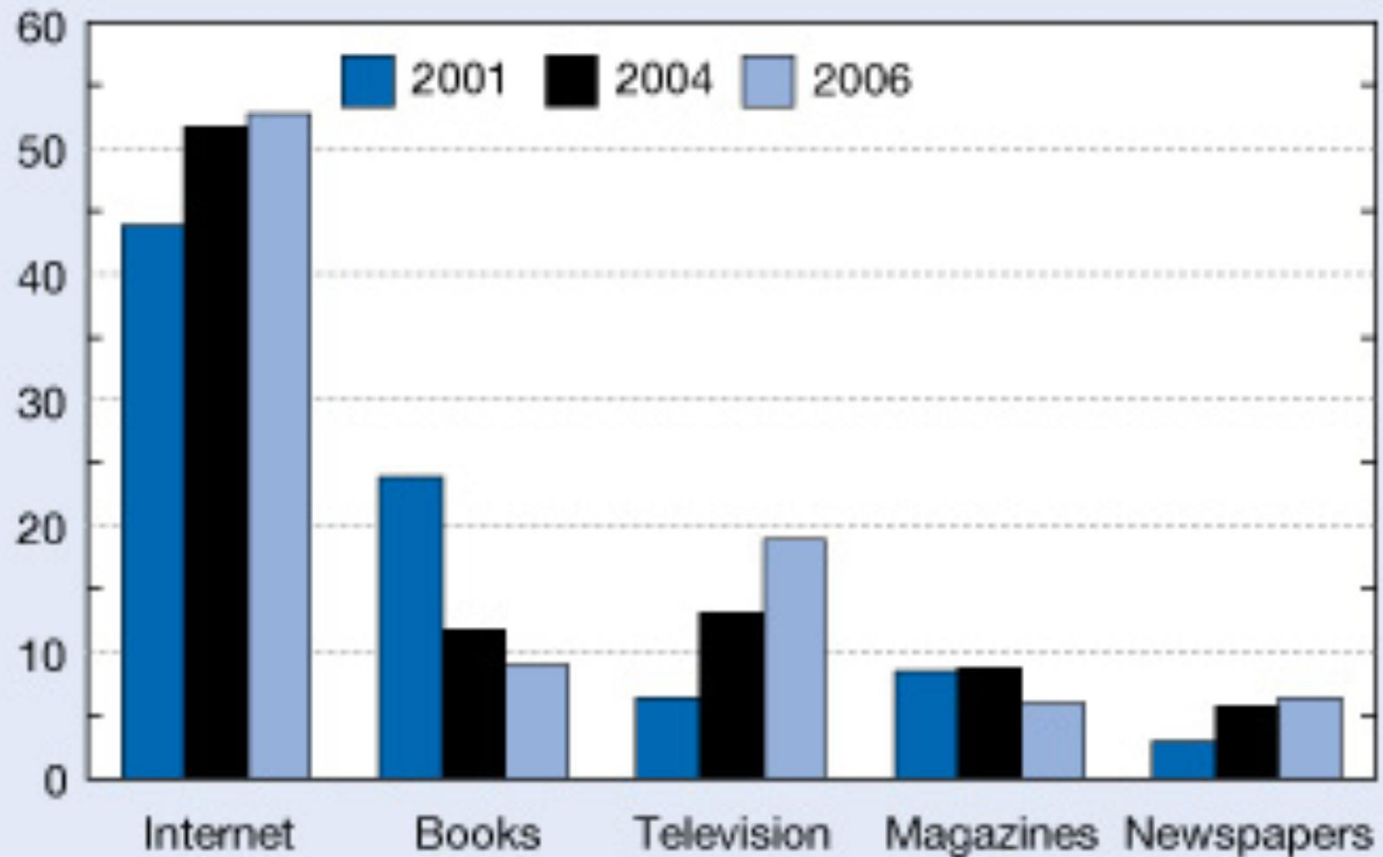
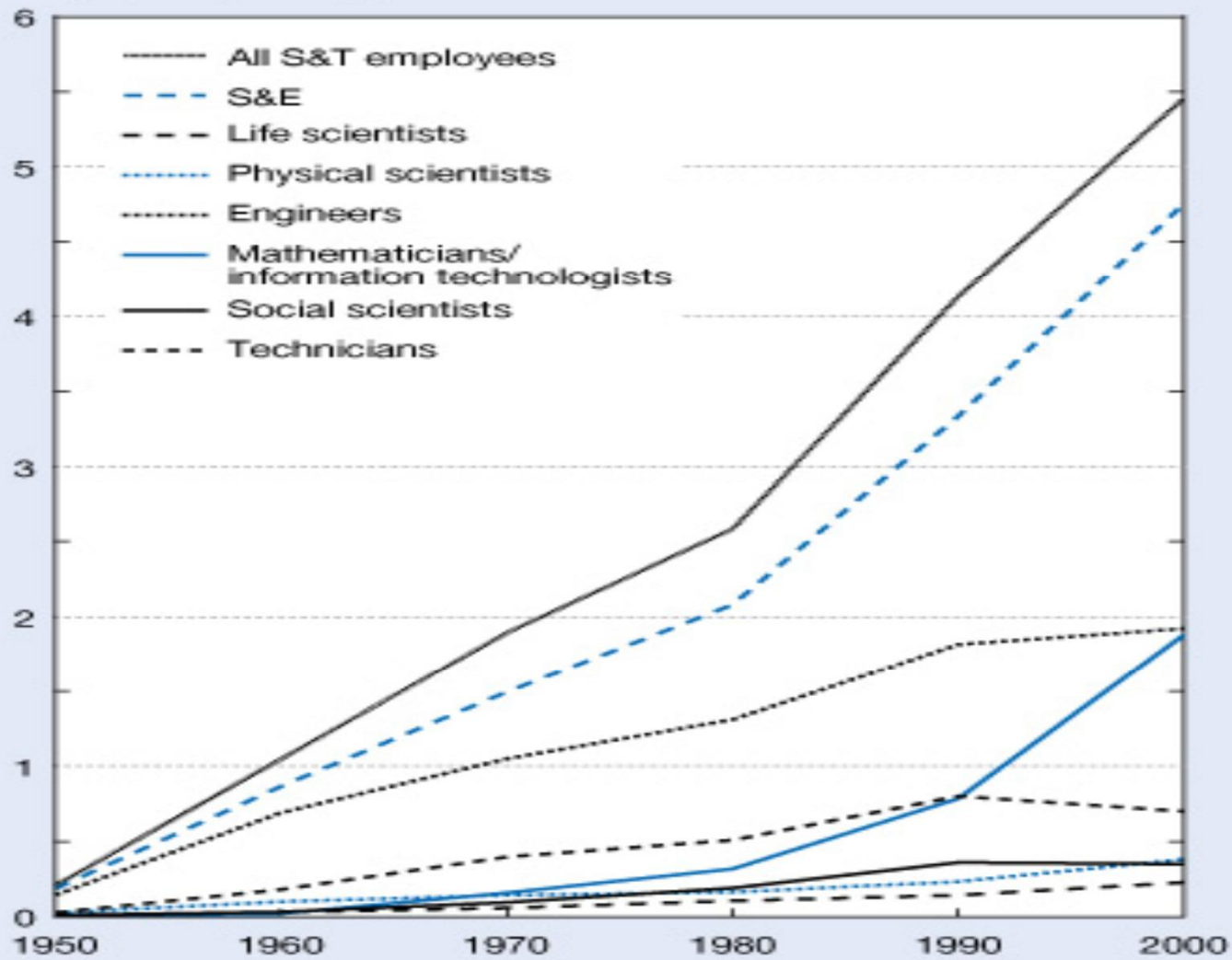


Figure 3-1  
**Science and technology employment: 1950–2000**

Employees (millions)



# How mathematicians do mathematics, communicate it, and publish it

Introduction by Roberto NATALINI

General discussion

How mathematicians interact with the « outer world »  
about their discipline

Introduction by Maria ESTEBAN

# How mathematicians interact with the « outer world » about their discipline

Introduction by Maria ESTEBAN

General discussion

How mathematicians deal with new trends like big data,  
etc.

Introduction by Peter BÜHLMANN

# How mathematicians deal with new trends like big data, etc.

Peter Bühlmann

Seminar für Statistik, ETH Zürich

# New trends: some history

- ▶ Felix Klein (1872): “Erlangen program” (Vergleichende Betrachtungen über neuere geometrische Forschungen)
- ▶ David Hilbert (ICM Paris, 1900): “The Hilbert problems” (10 problems in 1900; 23 in total)
- ▶ Henri Poincaré (1908): “L’avenir des mathématiques”
- ▶ Millennium Prize Problems (Clay Math. Institute, 2000) (7 problems; 6 are still open)

did the trends initiate

new activities for (specific) problem solving ?  
new frameworks, new theory, new connections ?



Felix Browder, AMS President (1999-2000),  
Reflections on the Future of Mathematics (2002):  
*“The most important area of bisociation\* lies in the **interaction between** mathematics and the sciences. One major external influence on mathematics is, of course, **the computer.**”*

\*bisociation: the creative act, which ... always operates on more than one plane (Koestler, 1964)

the theme today is slightly different:

how mathematicians **deal** with new trends?

I am not qualified to discuss the question in general, with a many mathematicians working in diverse exciting fields...

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# Big Data: mathematics, applied mathematics & statistics



data data data      Big Data: massive amounts of data

- ▶ because we have better measurement devices covering a huge range of fields, beyond engineering and natural sciences (e.g. “social networks”, ...)
- ▶ a hope for high societal value and business value

“modern” (exploratory) data analysis: Tukey (1960’s): **statistics**

huge data sets: Huber (1985), Wegman (1995), Donoho (2000): **statistics**

new data analysis: Gromov (1998), Carlsson (2009): **mathematics**

large-scale data: von Mehring et al. (2002), Kanehisa (2011): **comp. biology**

...

Big Data: ... Sutton (1998): **comp. science/machine learning**

~> the creation of Data Science !

... the “trend created” Data Science !

in the past: demand in applications broadened mathematics,  
leading to new fields such as

- ▶ Applied Mathematics
- ▶ Statistics
- ▶ Computational Sciences

is Data Science really of the same order of magnitude?

at least:

a major current trend, involving a huge number of scientists!

main aspect for mathematics and statistics:

analyzing the data; efficient and optimal information extraction

how do mathematicians deal with this?

*“Tukey (1960s) recognized Data Analysis as an emerging discipline, distinct from Mathematical Statistics and requiring its own literature”*

(Donoho; 2000, AMS “Math. Challenges of the 21st Cent.”):

~> a **separation**:

Anglo-Saxon “culture”: statistics separated from mathematics

Anglo-Saxon “culture”: biostatistics separated from statistics

(but reverse happens as well: comp. science and statistics move towards each other)

a **call for mathematics**: *“... Data Analysis movement has insinuated itself into every branch of society ... And the missing ingredient in facing those problems, it seems to me, is mathematics.”* (Donoho, 2000)



a **call for inter-“disciplinary” communication:**

because interaction with others opens new paths for exciting mathematics/statistics

examples (w.r.t. “Big Data”)

- ▶ Fast Fourier transform (Cooley and Tukey, 1965)
- ▶ Gibbs sampling (Geman and Geman, 1984)
- ▶ Compressed sensing (Donoho and Huo, 2001; Candes and Tao, 2005)
- ▶ many interesting mathematical works on high-dimensional analysis and approximation, topological and geometric invariants, computational-statistical trade-off,..

a call for inter-“disciplinary” communication:

because mathematicians/statisticians want to contribute to societal values

examples (w.r.t. “Big Data”):

- ▶ Michael Waterman



for gene sequencing (Smith and Waterman, 1981) which was crucial for the Human Genome Project (finished 2003)

- ▶ Terry Speed



Australian Prime Minister’s Prize for Science 2013:  
“For his contribution to making sense of genomics and related technologies (using statistics)”

# Lots of other trends (arising from “external sources”)

see e.g. Browder (2000):

- ▶ **the computer**: numerical methods and simulation
- ▶ the computer: mathematical optimization
- ▶ the computer: algorithms, graph theory and discrete mathematics
- ▶ **interaction between mathematics and the sciences**: mathematical physics, mathematical biology, mathematical chemistry,...
- ▶ interaction between mathematics and the sciences: mathematical modeling
- ▶ ...



# Summarizing thoughts

- ▶ historically, especially in “neighboring areas of” applied mathematics and statistics: fields and communities (departments) have split (recently, parts of Comp. Science and Statistics join forces)
  - can/should it be avoided?
- ▶ interaction and communication with external disciplines:
  - is it creating new conceptual frameworks?
  - a central part of mathematics?
- ▶ in need of mathematics ... in a huge amount of applications
  - how to respond to all the needs, given the small size of the mathematics community?
  - should we lead/co-lead collaborative efforts?  
should we “grab the opportunity” and become more highly visible?
- ▶ interaction opens new paths for exciting mathematics
  - can we improve the communication within and across the border of mathematics?

How mathematicians deal with new trends like big data,  
etc.

Introduction by Peter BÜHLMANN  
General discussion

# General Discussion

# Happy Birthday to the EMS!