




SANTA FE INSTITUTE

## Complex Systems Summer School 2014

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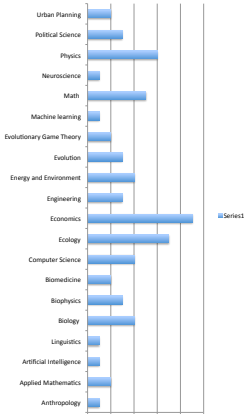
## Who are we?

- 60 Participants
  - 24 females
- 20 Nationalities
- Scientific backgrounds:
  - 21 Life sciences
  - 13 Math/Physics/
  - 6 Comp.Sc.
  - 18 Social sciences
  - 3 Engineering




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## Fields of research



Field	Count
Urban Planning	2
Political Science	2
Physics	5
Neuroscience	2
Math	5
Machine learning	2
Evolutionary Game Theory	2
Evolution	2
Energy and Environment	2
Engineering	2
Economics	9
Ecology	7
Computer Science	3
Biomedicine	2
Biophysics	2
Biology	3
Linguistics	2
Artificial Intelligence	2
Applied Mathematics	2
Anthropology	2

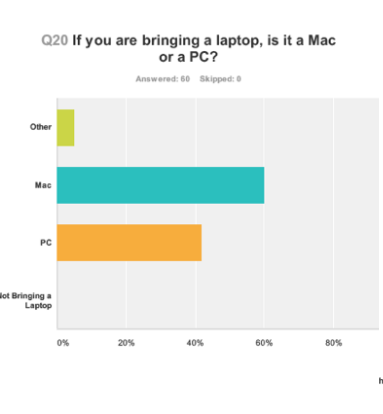


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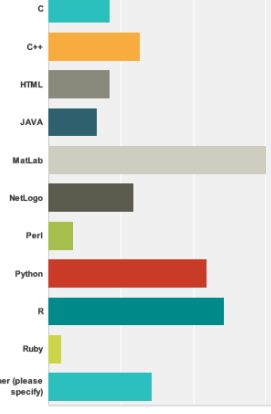
## Who are we

Q20 If you are bringing a laptop, is it a Mac or a PC?

Answered: 60 Skipped: 0



Category	Mac (%)	PC (%)
Mac	60	0
PC	0	42
Not Bringing a Laptop	0	0

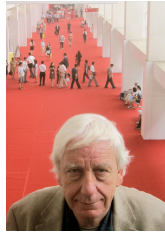
  


Language	Percentage
C	20
C++	25
HTML	15
JAVA	10
MatLab	60
NetLogo	25
Perl	5
Python	45
R	50
Ruby	5
her (please specify)	30

## Who am I?



- Sander Bais
  - University of Amsterdam
  - Science Faculty
  - Institute for Theoretical Physics
  - Institute for Interdisciplinary Studies
  - SFI (external faculty member)
- HEP, Part.Phys., Rel.Cosm., Cond.Mat., Stat.Phys., Top.Quant.Comp
  - Field theory, Relativity, String theory, CFT, TQFT
  - Topological features, (gauge and quantum) symmetries, dualities, phase structures, modelbuilding
- Popular Books:
  - The equations
  - Very Special Relativity
  - In Praise of Science
  - "...

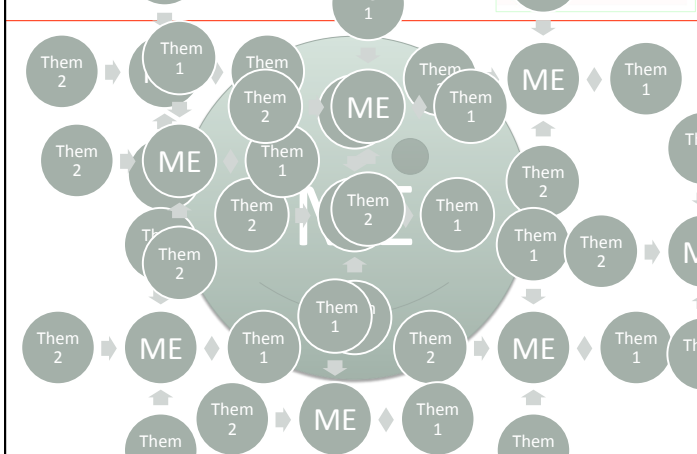


## CSSS: Who = Who?

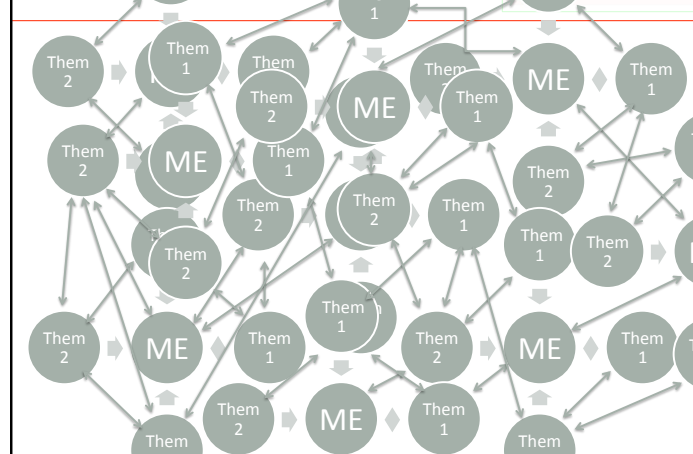


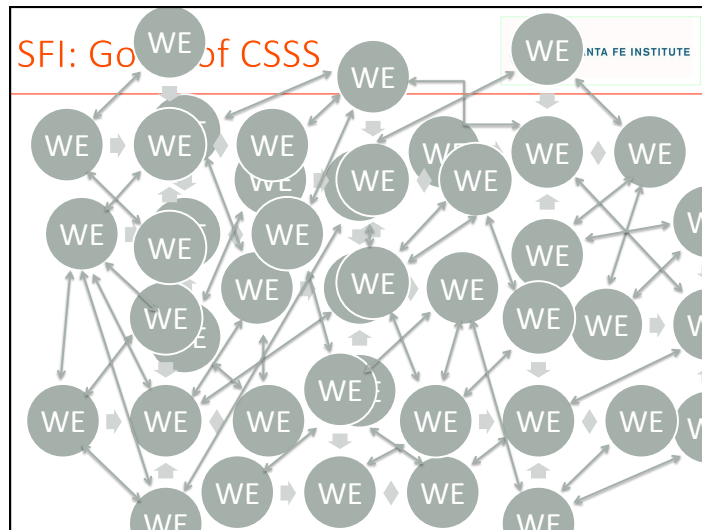
- Juniper Lovato
- John Paul Gonzales
- Miguel Fuentes and Josh Garland
- Ginger Richardson
  
- Food etc
- Computational facilities etc
- Shuttle services etc
- Other business

## SFI: Goals of the CS



## SFI: Goals of CSSS

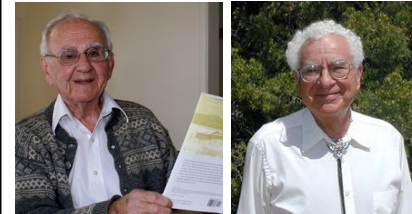




### SFI: history



- The Santa Fe Institute
- Founded in 1984 by small group of distinguished scientists, including 3 Nobel Laureates



George Cowan

Murray Gell-Mann

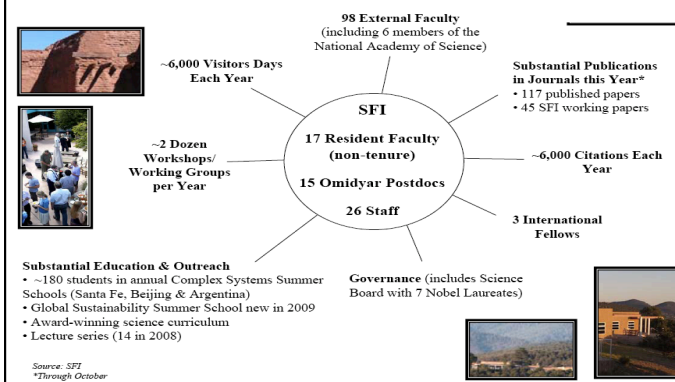
#### Strange Bedfellows

It is hard to think of a more unlikely collaboration than one between physicist and economist, but this is exactly what is going on at a dinner concert in Santa Fe, New Mexico.

Two names are mentioned: Murray Gell-Mann and George Cowan. The text describes their collaboration and the interdisciplinary nature of the institute.

Dr. Phil Anderson Dr. Ken Arrow

### SFI: A distributed network



Source: SFI  
\*Through October

Slide: M.Mitchell

### SFI: Research goals



- SFI is a research institute that
- *“pursues research on a large number of highly complex and interactive systems which can be properly studied only in an interdisciplinary environment”*
- and
- *“promotes a unity of knowledge and a recognition of shared responsibility that will stand in sharp contrast to the present growing polarization of intellectual cultures.”*

## SFI: 1984-2014



As SFI turns 30, we reflect on our first three decades in which a signature approach to science was born, a **new science** based on a revolutionary spirit and a dedication to inquiry without boundaries. We also look ahead to the next 30 years in which we will behold **new horizons** gained through a renewed commitment to the history and precepts that have shaped SFI and made it the intellectual hub of complex systems research worldwide. At SFI's core are exceptionally curious and talented **people** — some of the great scientific minds of our day. The **connections** that our scientists make — connections that link fields, ideas, and each other — result in a distinctive **opportunity** for innovative thinking about some of our most pressing problems. Our transdisciplinary approach gets to the heart of these issues, helping us gain fresh scientific **insights** — insights that, if used wisely, offer **hope** for improving the human condition.

## Education in complexity



I have been working in this area for over thirty years now and, in that setting, I feel we, or at least I, have failed our students. To my taste, there has been too little synthesis and too much competition. The result is dilution of the original spirit and insight. (How ironic for a field whose central goals is to understand emergence.) One central cost has been a lack of cooperation to build training programs.

On the up side, much progress has been made in the research arena. Now is the time to take the (perhaps substantial) effort to rework those results so that students can be introduced to te concepts systematically.

The goal is that they learn deeply enough to extend them creatively to attack the many remaining, truly complex problems.

Jim Crutchfield

## SFI: Outreach and education



- Complex Systems Summer School
- Computational Social Sciences Summer School
- Global Sustainability Summer School
- Graduate and undergraduate research opportunities
- K-12 student and teacher science education (e.g., "Project GUTS", GUTsy Girls, High School Science Excellence Awards, etc.)
- "Exploring Complexity" short courses, MOOCs
- Topical short courses

## SFI: Output



- Working paper series
- Book series (published by Oxford University Press)
- Bulletin of the Santa Fe Institute
- Colloquia, seminars, etc. on video and in public media
- Complexity Explorer web site
- Prototype of a Complexity Institute

## SFI: Goals of the CSSS



- For you to come away with much more and much deeper understanding of the range, significance, and current directions of complex systems science.
- To help provide new ideas and tools for understanding complex (biological, social, financial, computational, physical) systems and their behavior.
- For you to find novel ways to apply the information and methods you learn here in your own research context.
- Form a horizontal transdisciplinary network with fellow participants sharing insights, experiences, and inspiration.

## SFI: research profile



Themes:

- [Physics and Computation of Complex Systems](#)
- [Human Behavior, Institutions, and Social Systems](#)
- [Living Systems: Emergence, Hierarchy, and Dynamics](#)

Projects:

- [Cities, Scaling and Sustainability](#)
- [Evolution of Complexity on Earth](#)
- [Hidden Laws in Biological and Social Systems](#)
- [Emergence of Complex Societies](#)

## SFI: Research profile

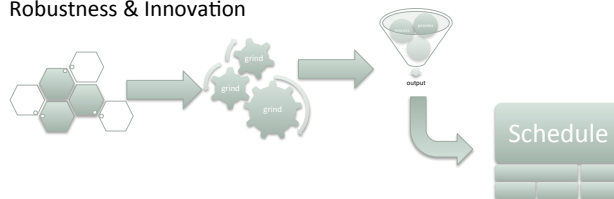


**SFI (Profile = Network)**

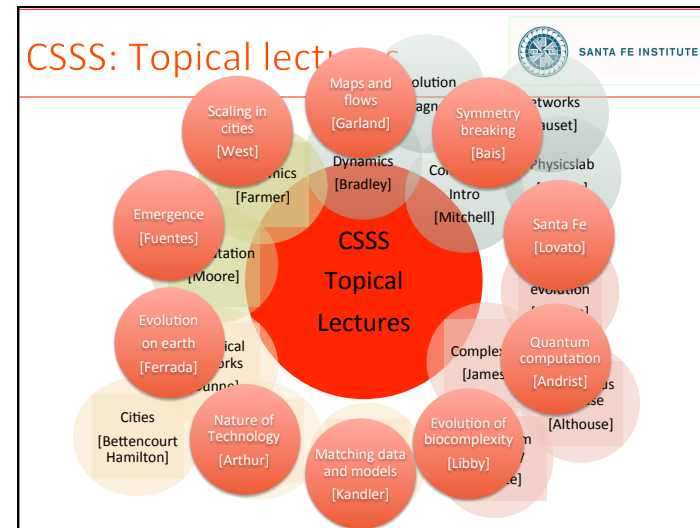
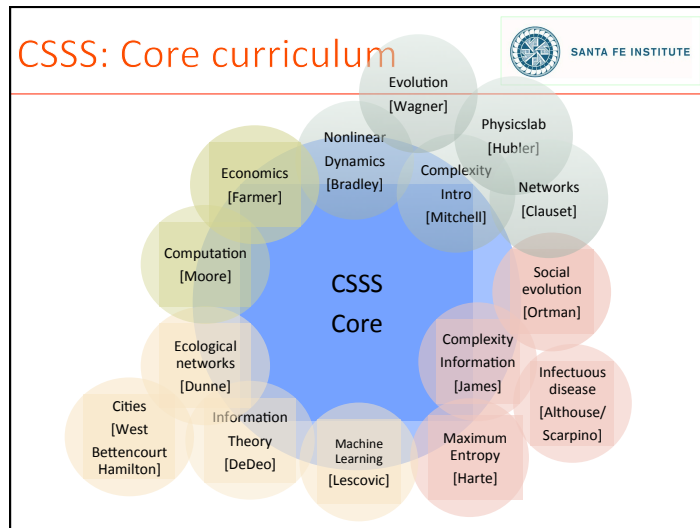
- Behavioral Dynamics
- Evolution & Emergence
- Information & Computation
- Physics of Complexity
- Robustness & Innovation

**CSSS**

A network of topics



Year	Project	PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI	Co-PI
2010	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2011	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2012	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2013	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2014	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2015	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2016	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2017	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2018	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2019	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2020	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2021	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2022	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2023	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2024	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde
2025	Complexity in the Brain	Walter J. Freeman III	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde	David R. Forde



### SFI: Research profile

<p><b>SFI</b></p> <ul style="list-style-type: none"> <li>• Physics and Computation of Complex Systems</li> <li>• Human Behavior, Institutions, and Social Systems</li> <li>• Living Systems: Emergence, Hierarchy, and Dynamics</li> </ul>	<p><b>CSSS</b></p> <ul style="list-style-type: none"> <li>• Chris Moore: Nature of Computation</li> <li>• Ryan James: Complexity/Information</li> <li>• Melanie Mitchell: Agent based modeling</li> <li>• Joshua Garland: Dynamics Lab</li> <li>• Alfred Hubler: Computer Lab</li> <li>• Jure Lescovics: Machine learning</li> <li>• Rubin Andrist: Quantum computation</li> </ul>
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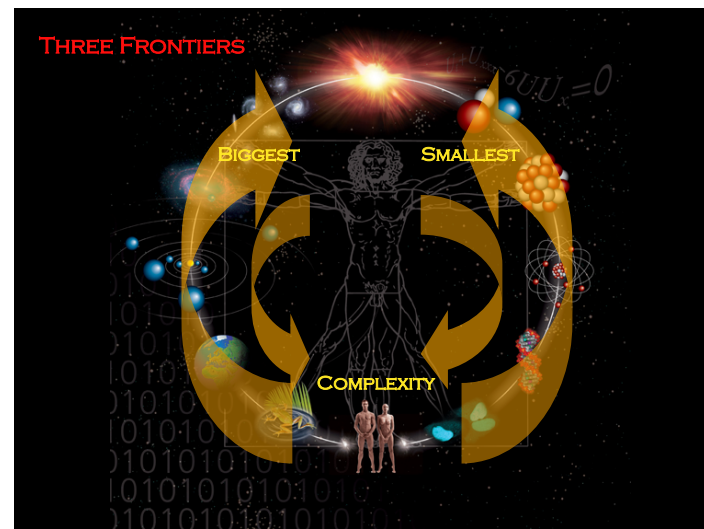
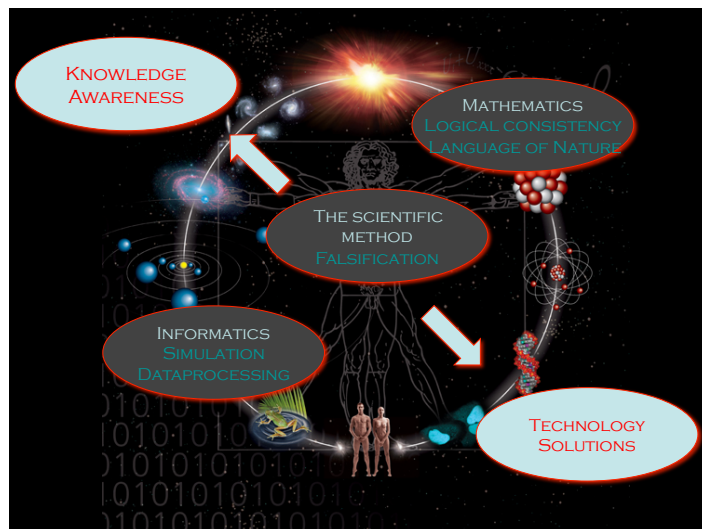
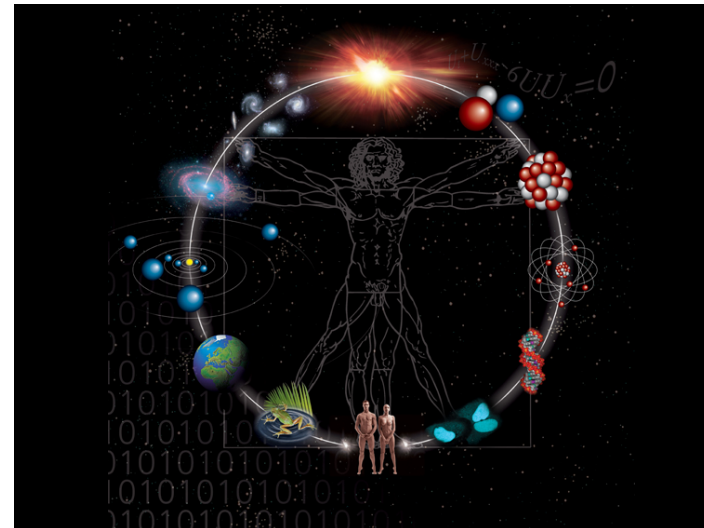
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## SFI: Research profile

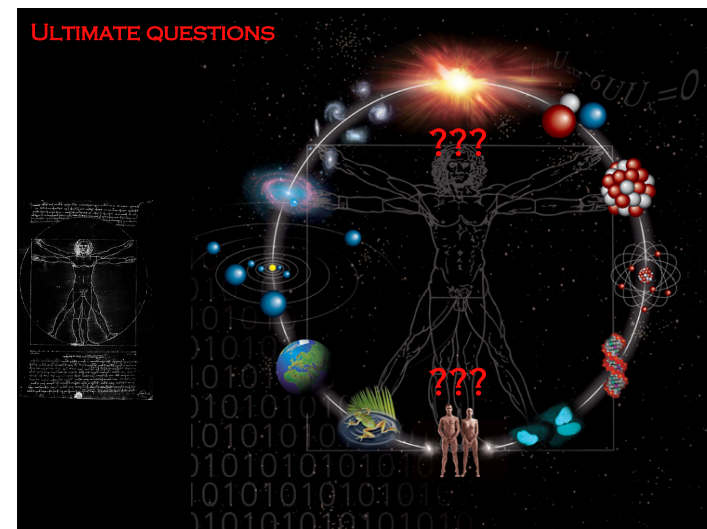
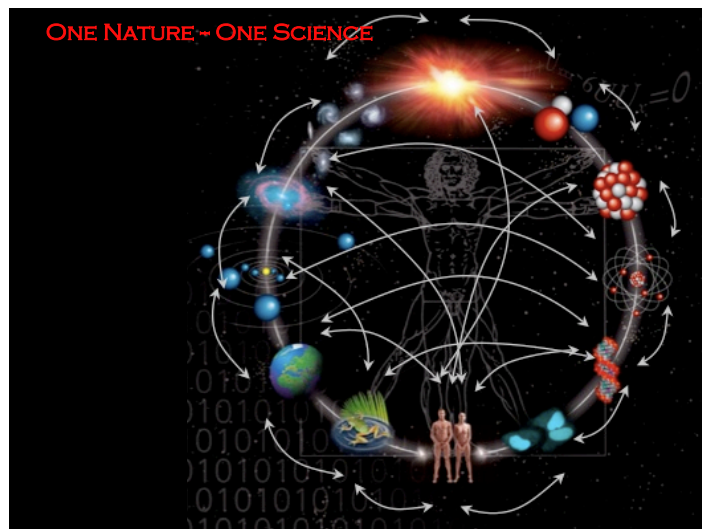
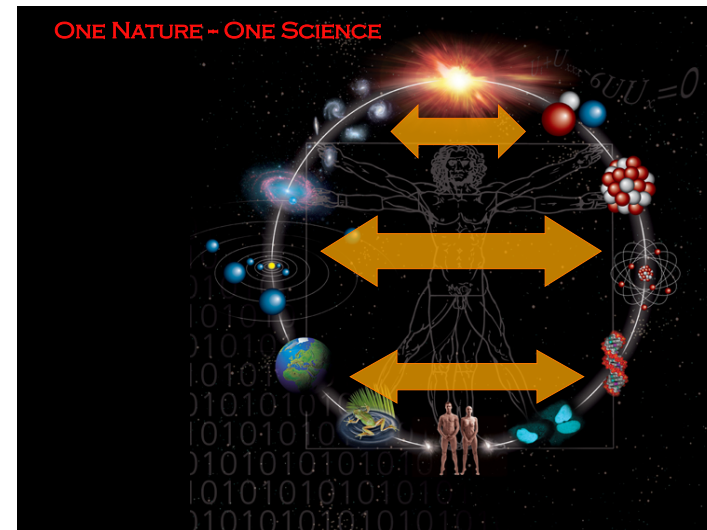
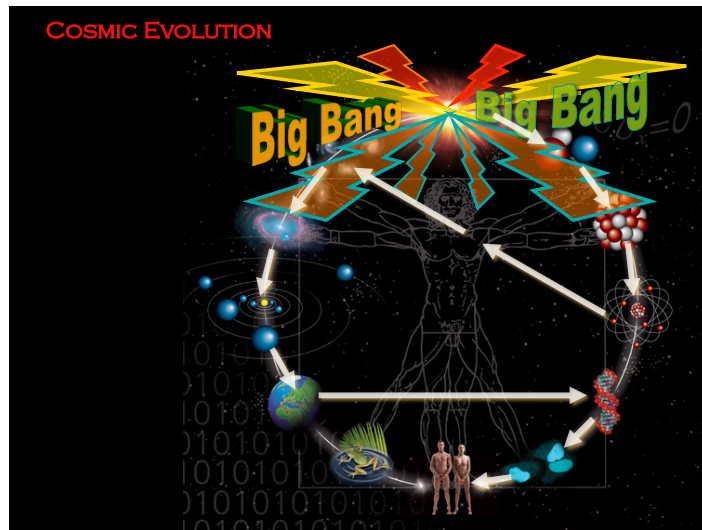


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## Albert Einstein 1918

"The most important task for scientists is to search for the most fundamental laws, from which a picture of the world can be deduced. There is no logical path that leads to these elementary laws, only an intuitive one, based on creativity and experience.

With such a methodological uncertainty one would think that an arbitrary number of equally valid systems would be possible. However, history shows that of all conceivable constructions always a single one did stand out as absolutely superior to all others."

## Max Perutz 1994

"Discovering its structure was wonderful. You must imagine the time when proteins were black boxes. Nobody knew what they looked like. There I was, having worked on this vital problem for twenty-two years, trying to find out what this molecule looked like, and eventually how it worked. When the result emerged from the computer one night and we suddenly saw it, it was like reaching the top of a difficult mountain after a hard climb and falling in love at the same time. It was an incredible feeling to see this molecule for the first time and to realize that my work had not been in vain: because during those long years I feared that I was wasting my life on a problem that would never be solved."

## Richard Feynman 1981

"You see, one thing is, I can live with doubt and uncertainty and not knowing. I think it's much more interesting to live not knowing than to have answers which might be wrong. I have approximate beliefs and different degrees of certainty about different things, but I'm not absolutely sure of anything and there are many things I don't know anything about, such as whether it means anything to ask why we're here..."

I don't know the answer. I don't feel frightened by not knowing things, by being lost in a mysterious universe without any purpose, which is the way it really is as far as I can tell, it doesn't frighten me."