

**HIGH COGNITIVE COMPLEXITY  
AND  
RADICAL BREAKTHROUGHS**

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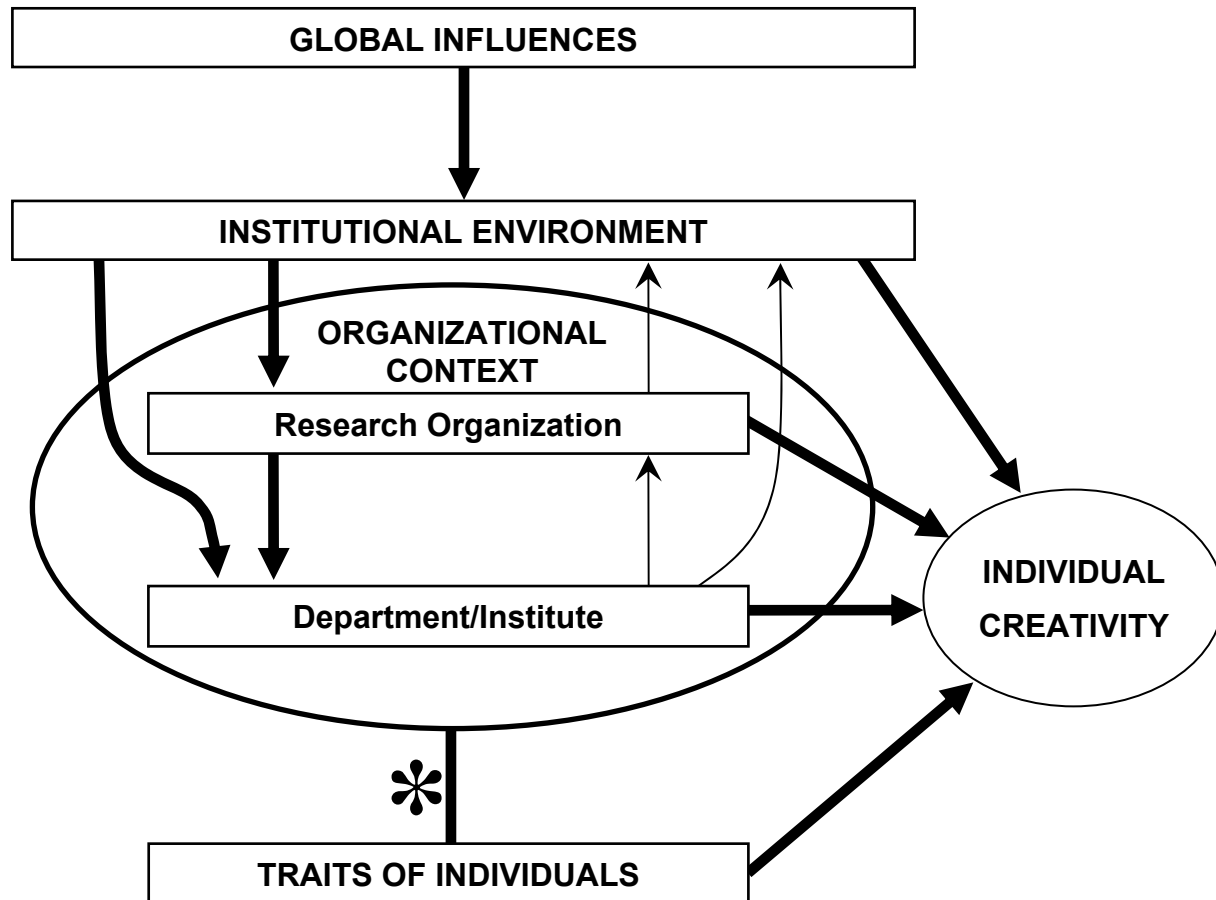
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- (1) What were some of the traits at the level of individuals which influenced their creativity and the making of major discoveries?**
- (2) How did institutional and organizational factors facilitate or hinder creativity and the making of major discoveries?**
- (3) How did the global economic environment of these four countries facilitate or hamper creativity and the making of major discoveries?**

# Factors at Multiple Levels Influencing Individual Creativity in Basic Biomedical Science



**\*Each organization attempts to recruit individuals who complement its culture and structure**

# Definition of a Major Discovery

A major breakthrough or discovery in biomedical science is a finding or process, generally preceded by numerous “small advances,” which leads to a new way of thinking about a problem. This new way of thinking is highly useful in addressing subsequent problems by numerous scientists in *DIVERSE* fields of science. Historically, a major breakthrough in biomedical science was a radical or new idea, the development of a new methodology, a new instrument or invention, or a new set of ideas. It has usually not been something which occurred all at once, but involved numerous experiments or a process of investigation taking place over a substantial period of time.

# Indicators of Major Discoveries

1. Copley Medal
2. Nobel Prize for Physiology or Medicine
3. Nobel Prize for Chemistry
4. Ten nominations in three years for Nobel Prize for Physiology or Medicine
5. Ten nominations in three years for Nobel Prize for Chemistry
6. Prizeworthy in Physiology or Medicine
7. Prizeworthy in Chemistry
8. Lasker Prize in Basic Science
9. Louisa Gross Horwitz Prize
10. Crafoord Prize

# **Traits Facilitating Creativity of Individuals**

# **TABLE ONE**

## **Scientists Who Made Major Discoveries in Basic Biomedical and Related Sciences 1901–2007**

- 1) Scientists Awarded Nobel Prizes in  
Physiology or Medicine**
- 2) Scientists Awarded Nobel Prizes in Areas  
of Chemistry Relevant to Basic  
Biomedical Science**
- 3) Scientists Awarded the Lasker Award in  
Basic Biomedical Science**
- 4) Scientist Awarded the Louisa Gross  
Horwitz Prize in Basic Biomedical Science**

## **TABLE TWO**

### **Highly Creative Twentieth Century Scientists Who Were Also Quite Active In Music, Art, Writing, Crafts, Politics, and Avid Readers of Serious Literature**

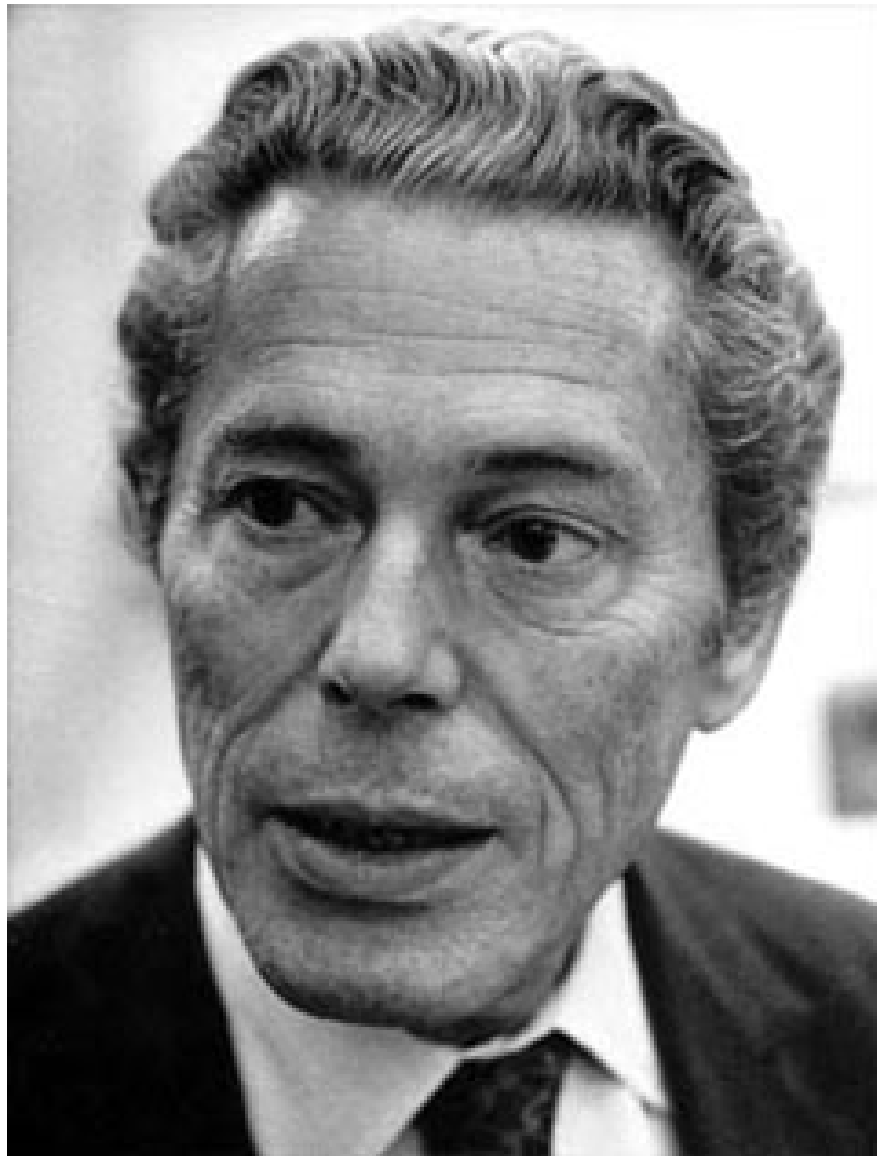
- **Musicians**
- **Composers of Music**
- **Poets**
- **Dramatists**
- **Novelists**
- **Painters and Sketchers**
- **Sculptors**
- **Drafters**



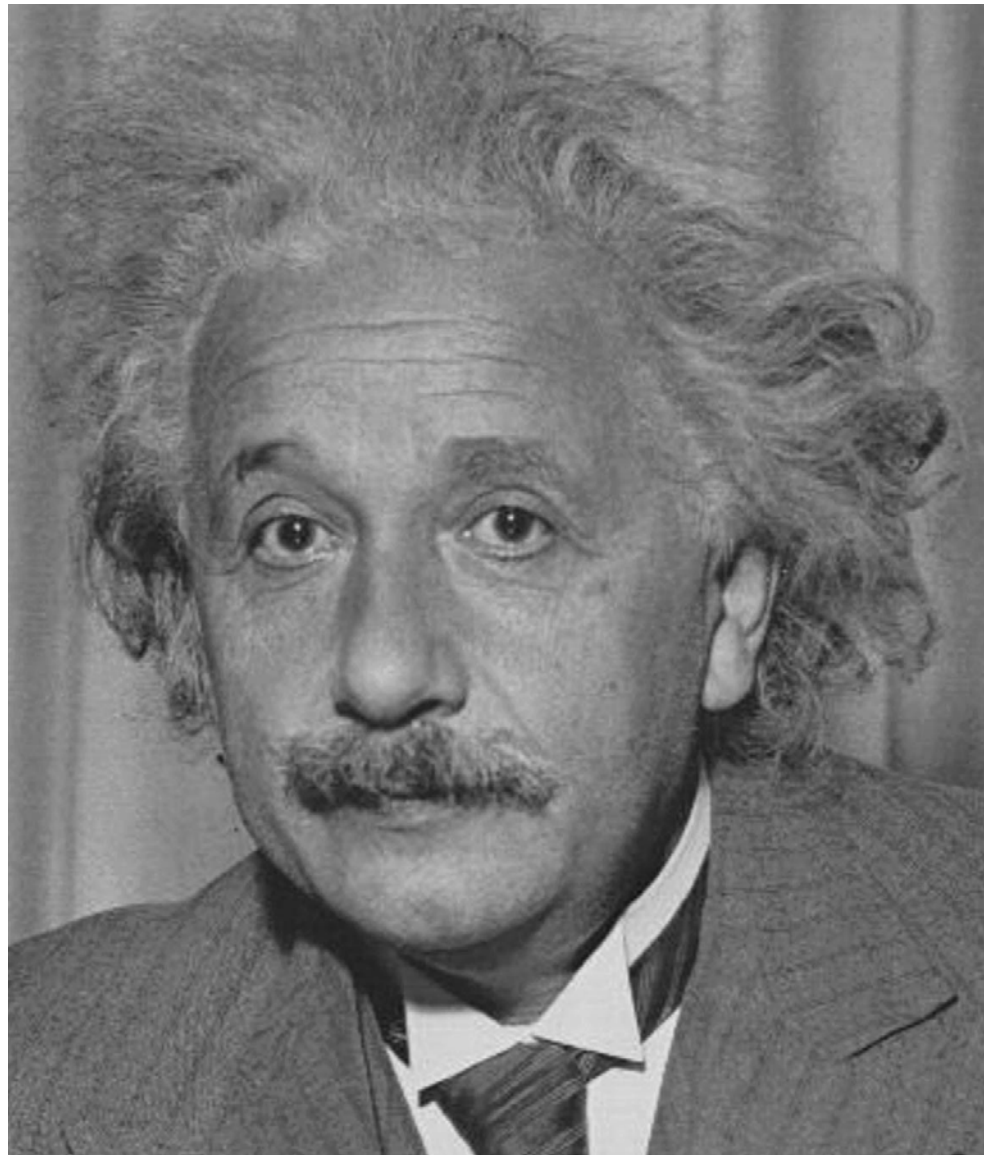
## **TABLE TWO**

**Highly Creative Twentieth Century  
Scientists Who Were Also Quite Active In  
Music, Art, Writing, Crafts, Politics, and  
Avid Readers of Serious Literature**

- **Involved in Architecture**
- **Photographers**
- **Woodworkers or Metalworkers**
- **Scientists Who Wrote Philosophy,  
History, Anthropology, and/or  
Popular Science**
- **Avid Readers of Serious Literature**
- **Political Activists**



**Jacques Monod**



**Albert Einstein**



**Niels Bohr**



**James Watson ~ Francis Crick**

# **Creativity in Science and Art**

- 1) Similarities and differences among creative individuals in the arts and sciences**
- 2) Centers of high creativity**

**Institutional Factors  
Facilitating or Hampering  
Scientific Creativity**

# Weak Institutional Environments

1. Weak Control over Personnel
2. Weak Control over Scientific Disciplines
3. Weak Control over Funding for Scientific Research
4. Many Different Types of Training Systems
5. Strong Normative Environment for High Risk Research



# Strong Institutional Environments

1. Strong Control over Personnel
2. Strong Control over Which Scientific Disciplines Will Exist in an Organization
3. Strong Control over Funding for Scientific Research
4. Strong Prescription of Level of Training Necessary for a Scientific Appointment
5. Strong Control over Scientific Entrepreneurship

**The Impact of the Structure  
and Culture of Research  
Organizations on Individual  
Creativity**

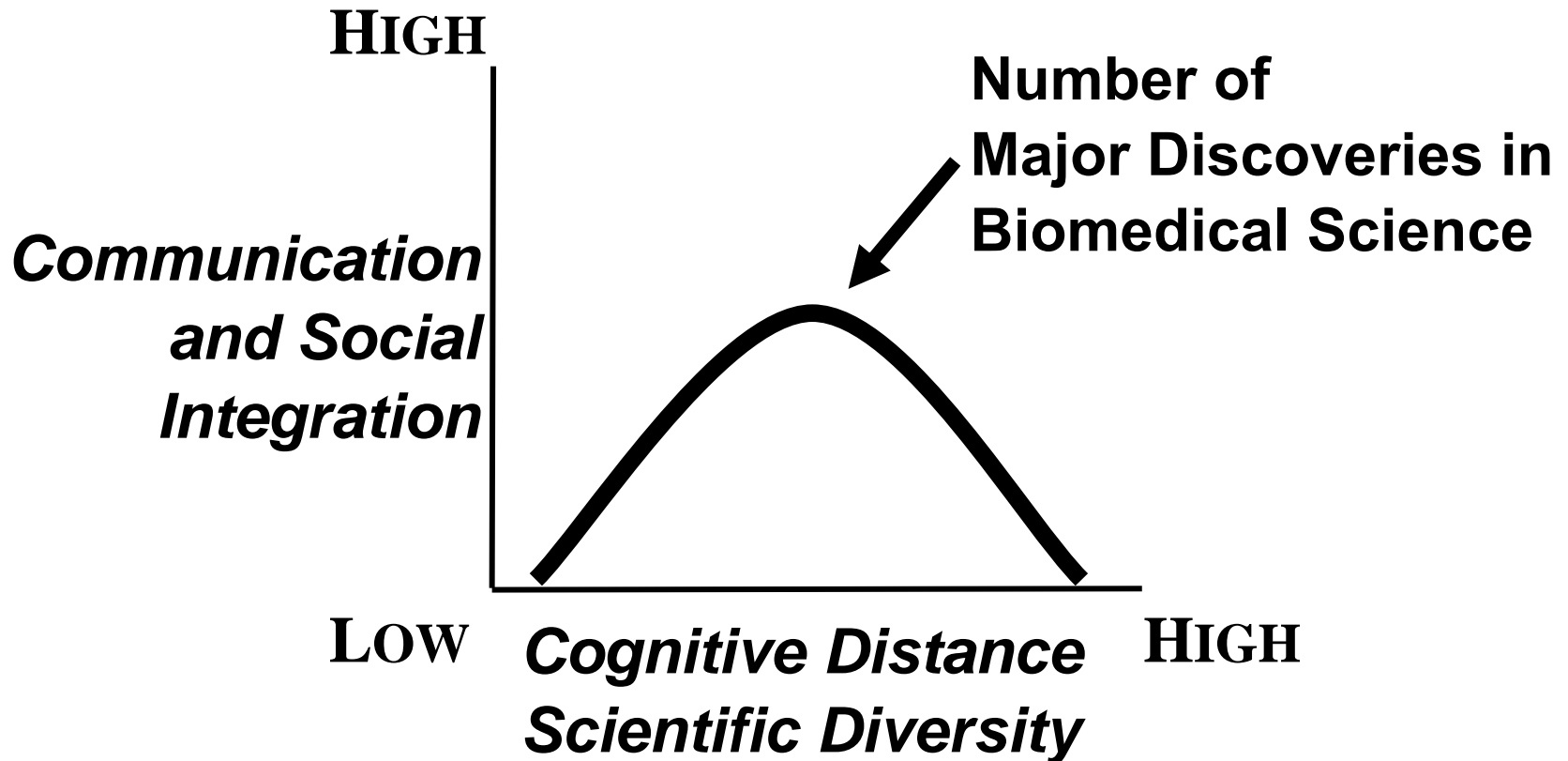
# What qualities of an organization facilitate making major discoveries?

- ▶ Moderately high scientific diversity
- ▶ Capacity to recruit scientists who internalize scientific diversity
- ▶ Communication and social integration of scientists from different fields through *frequent* and *intense* interaction
- ▶ Leaders who integrate scientific diversity, have the capacity to understand the direction in which scientific research is moving, and provide rigorous criticism in a nurturing environment
- ▶ Flexibility and autonomy associated with loose coupling with the institutional environment

# What qualities of an organization hamper the making of major discoveries?

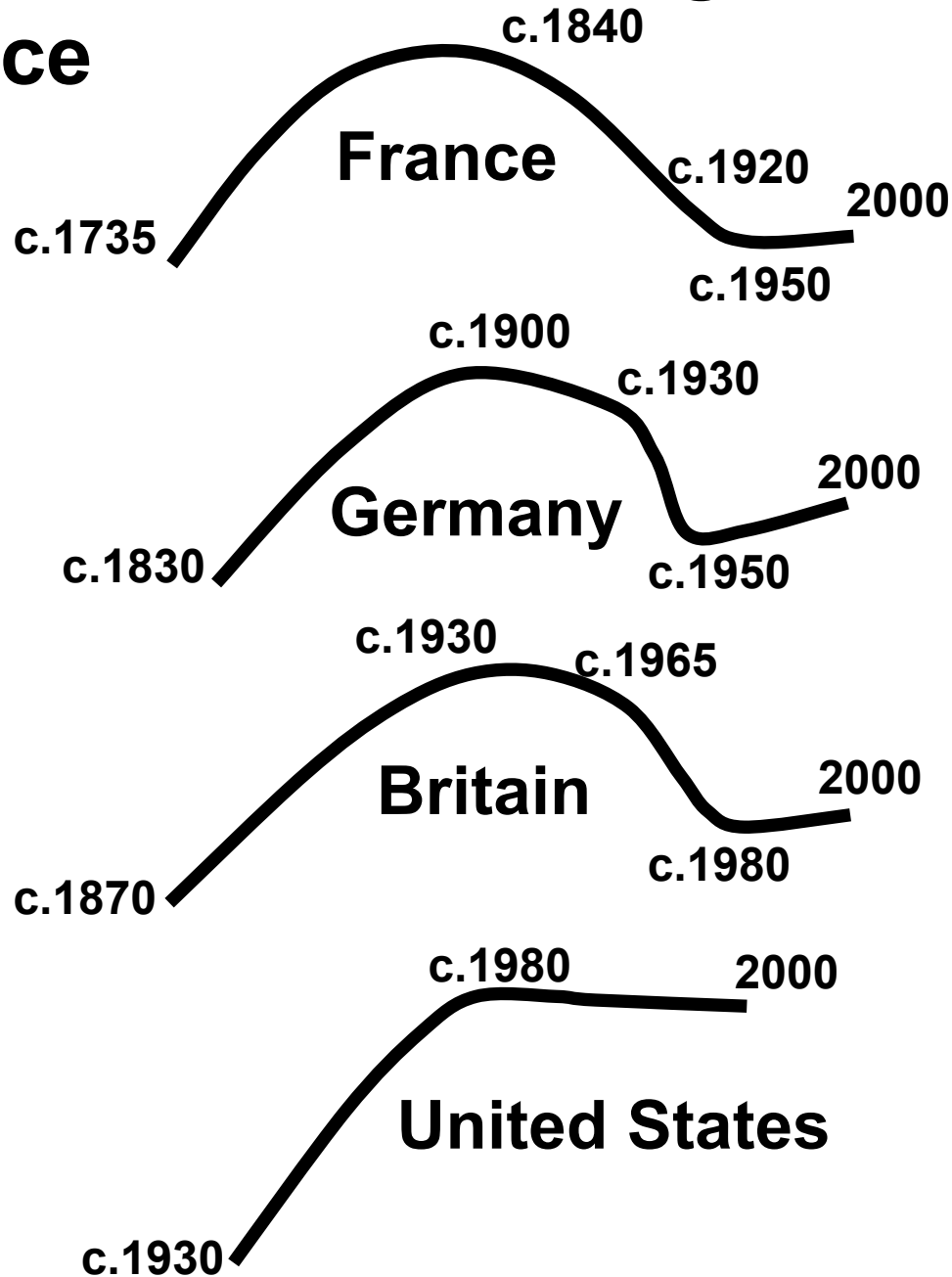
- ▶ High differentiation – sharp boundaries among subunits such as departments, divisions, or colleges
- ▶ Hierarchical authority – centralized decision-making about research programs, number of personnel, work conditions, and/or budgetary matters
- ▶ Bureaucratic coordination – high standardization of rules and procedures
- ▶ Hyperdiversity – diversity to the degree that there cannot be effective communication among actors in different fields of science

# The Impact of Communication and Cognitive Distance on Making Major Discoveries in Biomedical Science



# **Changes in the Spatial Distribution of Scientific Creativity**

# The Rise and Decline of Hegemonic Systems of Science







**David Gear  
and  
Ellen Jane Hollingsworth  
made enormous contributions  
for this presentation**