Academia and Industry Research: Are they different beasts?

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DISCLAIMER

The views expressed in this talk are entirely my own and may not represent in any way the views of Alcatel-Lucent.
What?

Lessons learned through all my years doing research
Things I wish I knew early on in my career

Straight advice and insights to build a healthy research career and life!
Why should you care?

Most of us will find ourselves at this professional crossroad.

Whether we choose academia or industry careers we need to understand and complement each other better.
Outline

➢ Part I:  RESEARCH FOUNDATION, EVOLUTION, AND CHALLENGES

➢ Part II:  ESSENTIAL ELEMENTS OF GREAT RESEARCH

➢ Part III:  KEYS TO PROFESSIONAL SUCCESS

➢ Part IV:  ROUND-UP
Outline

➢ Part I: RESEARCH FOUNDATION, EVOLUTION, AND CHALLENGES

❖ What really is research?
❖ How do academic and industry research differ?
❖ What are top common challenges we must face?
❖ What is Industry’s top challenge?
What is Research?

A new perspective

“Research is to see what everybody else has seen, and to think what nobody else has thought”

Albert Szent-Gyorgyi (Hungarian Biochemist, 1937 Nobel Prize for Medicine)

A quest for clarity

“If we knew what it was we were doing, it would not be called research, would it?” Albert Einstein

“Research is what I’m doing when I don’t know what I’m doing.”

Werner von Braun (leading German rocket scientist and astronauts engineer)
What is Research? (cont.)

- **A process to seek understanding** (web definitions)
  - Research is an organized and systematic way of finding answers to questions
  - Systematic investigation to establish facts
  - A systematic study directed toward fuller scientific knowledge or understanding of the subject studied.
  - Investigation intended to extend the limits of human knowledge

Research is the methodic process of seeking understanding of a seemingly complex subject until its simple essence is discovered
Goals and Nature of Research

**Academic Research**
- Seeks understanding as the end goal
- Aimed at producing new thinkers and new knowledge for recognition

**Industry Research**
- Seeks innovation as the end goal
- Aimed at producing new useful technology for profit (products/applications/services)

- Critical thinking drives the quest for understanding and innovations
- Understanding <-> Innovations
- Aims, motives, output and timeframes differ
- Quest is similar.
Types of Research

**Basic Research**
Quest for fundamental understanding

**Applied Research**
Quest for value-driven understanding

**Opportunistic Research**
Quest for exploitation-driven understanding
Types of Research: Basic

**Basic Research**

- Formulate a problem in a highly abstract manner
- Try to capture its essence with analyzable models
- Discover a fundamental property/structure and/or address a fundamental deficiency/weakness

Example: Computing theoretical capacity limits on an information channel

**PRO’S**
- Needs minimal resources compared to other research
- Impact can be broad & transformational

**CON’S**
- Impact value not a priority
- Time to impact unpredictable, usually very long-term
- Highest investment risk
Types of Research: Applied

**Applied Research**

- Analyze problem at relatively low level of abstraction
- Capture salient constraints/features inherent in real-world implementation
- Discover novel solutions that impact how practical systems may be built or managed

Example: Increasing capacity throughput in a given information channel

**PRO’S**
- Impact value is critical
- Shorter time to impact
- Lower investment risk

**CON’S**
- Analytical complexity very high
- Needs more resources
- Usually incremental impact
Types of Research: Opportunistic

- Analyze real problem focusing on current technology constraint known to be temporary
- Discover innovative way to circumvent or exploit the constraint for a valuable practical gain

Example: Increasing wireless per-user bandwidth with discrete, hardware-limited transmission frequencies

**PRO’S**
- Shortest time to impact
- Lowest investment risk
- Fastest return on investment

**CON’S**
- Very narrow impact scope
- Short shelf-life
TRUE!

All Opportunistic research is Applied but not all Applied research is Opportunistic.

Applied Research that seeks impact beyond current technology limitations is not opportunistic.
TRUE OR FALSE?

Academic research is either Basic or Applied but rarely Opportunistic.

As academic research budgets decrease, research becoming increasingly Opportunistic.
**FALSE!**

*Basic research is dead in American Industry.*

Though most research is Applied or Opportunistic, Basic Research is still supported (albeit, very limited).
TRUE OR FALSE?

While computer scientists do research, engineers just build systems.

Engineers prefer confirmatory research while scientists prefer exploratory research but both are valid research strategies.
Many Dimensions of Research

➢ Research Essence: THINK and produce NEW IDEAS

➢ Fundamental Dimensions
  ❖ Consumer
    ❖ Who’s funding? Academia, Industry, Government
  ❖ Time to Impact
    ❖ Short-term (0-5 yrs), Medium-term (6-10 yrs), Long-term (10+ yrs)
  ❖ Scope
    ❖ From General to highly Applied (narrow)
  ❖ Value (viewed as Technology Impact)
    ❖ Low (irrelevant), Medium (incremental), High (disruptive)
Academic and Industry Research: Ideals

**Academia**
Strives for ideas that are disruptive, general and have medium to long-term impact

**Industry**
Strives for ideas that are incremental to disruptive, fairly applied, and have short-term impact
Academic and Industry Research: Realities

Academia

Produces ideas that are mostly incremental, increasingly applied and shorter-term impact

Industry

Produces ideas that are mostly incremental, very applied, and have medium-term impact

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<th>VALUE</th>
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Produces ideas that are mostly incremental, very applied, and have medium-term impact
Academic and Industry Research: Realities

- Research priorities are dynamic and shift depending on available funding
  - Good economic times: strive towards ideals
  - Bad economic times: shift away from ideals towards achievable shorter term goals

- In today’s money-strapped Academic and Industry research
  - Both dominated by *incremental, applied* research
  - Both striving to *reduce time-to-impact*

- Research agendas are not resistant to changing economy regardless of where you are
- Dynamic shifts are more frequent and severe in Industry, where short-term accountability is much stronger
Top Industry Research Challenge

Closing the R&D gap

- Known as the “Technology Transfer Problem”
- Refers to process of taking new research ideas and developing into practical products
- Makes or breaks Industry’s realized value of having a research engine

- Tradeoffs and Challenges are highly dependent on size of the company
Innovation Realities

A great idea is just the beginning!

I call it “The Wheel”

I can’t see it catching on

Does it come in any other colours?

Venture Capital

R and D

Marketing

www.firstdogonthemoon.com
Innovation Woes

There are many challenges on the path to realization.
Innovation in Medium/Large Companies: Barriers

- **Legacy** support of deployed products/services - huge overhead!
- **Expected compliance** with industry standards and processes - huge overhead!
- **Internal competition**: new products often threaten to displace company’s own revenue-generating products and people - huge risk!
- **Teamwork inefficiencies** between separate R&D organizations
- **Entrenched cultural barriers** to change
Innovation in Medium/Large Companies: Barriers

"Your proposal is innovative. Unfortunately, we won't be able to use it because we've never tried something like that before."
Innovation in Medium/Large Companies: Assets

- Availability of **research funds** and resources feasible
- Can afford **research breadth** proportional to the size of its revenue
- Opportunity to leverage **understanding of real problems** experienced by large customer base
- Can leverage **pre-existing development engine** and improve existing products
Innovation in Small Companies: Barriers

- **Development focus**: Research usually non-existent
- **Limited resources to fight competition** in the marketplace, courtroom, publicity channels - easily squelched by giant competitors
- **Limited/no standards-compliance** for features or development processes
- **High overhead** to establish **brand recognition** and customer **trust**
- **Huge risk** for survival - 1/10 startups survive
- **Employee churn** due to burn-out, job stability, etc.
Innovation in Small Companies: Assets

- **Innovative company mission** - great respect for new idea triggering its inception
- **Faster and leaner production** cycles leading to faster innovation
- **Teamwork** is efficient, cooperative, highly-driven - tech transfer not a big problem
- **Nimble** workforce
Capturing Best of Both: A Tech Transfer Model that Works?

IDEA: Create small, startup-sized team of innovators comprising researchers and developers with a single-minded mission to productize a research idea

- Remove burden from most parent company overheads
- Leverage effectively parent company expertise, resources, and outlet channels (legal, marketing, customer base, etc.)
- Build-in appealing risk-reward structure to motivate and mitigate employee risks

Example: Alcatel-Lucent Ventures
- In operation for the last 5 years, has productized a variety of research ideas, leading to award-winning products
  Laptop security, advanced IP routing, wireless (security & network management, simplified WAN access networks, location-based services)…
Another Idea: A Tech Transfer Facilitator

IDEA: A smart Problem-Solution matching web-tool

Recent initiative at Lockheed Martin’s ATL (Advanced Technology Lab) [Buskens]

- Academia has lots of solutions looking for problems
- Industry has lots of problems looking for solutions
- Designed to enable and maximize opportunities for real research impact
Complexity: Our Common Research Enemy

...and Our Future Job Security

Our ability to build useful, complex systems has far surpassed our current understanding of how they work and how they are to be managed.

Desperate need for simplicity

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius -- and a lot of courage -- to move in the opposite direction."  Albert Einstein

- Systems have evolved from being simple organs to large and complex organisms and ecosystems
- Recent trend of new cross-disciplines
  - NetSE: Network science and Engineering [Zegura, et.al]
Fighting Complexity is Hard

- **Inadequate abstractions**: simplistic, tractable analytical models of the past are often far too idealized to learn much of anything useful from them
  - Mathematical rigor is critical, but increasingly elusive

- **Need for large-scale validation methods**: Dynamics of highly complex systems can no longer be studied and validated with small-scale systems.
  - PlanetLab
  - GENI network testbed, (Global Environment for Network Innovations)
  - CAIDA’s Internet backbone traffic traces
Unclear future CS field milestones and success metrics: Lack of consensus on how to measure field’s progress, vision for growth

- Lots of controversy around GENI initiative:
  Should networking growth be Darwinian or revolutionary?
- New high-visibility initiatives to defend field’s value and chart clear vision for growth
  Priority for CRA’s new Computing Community Consortium [Lazowska, et.al]

“To create compelling research visions and the mechanisms to realise those visions.”
Complexity and the Call for Ethical Responsibility

Today’s complexity issues are nothing compared to the complex ethical and societal issues that are emerging.

Read: Bill Joy’s WIRED article, “Why the Future Doesn’t Need us”, April 2000

“Our most powerful 21st-century technologies - robotics, genetic engineering, and nanotech - are threatening to make humans an endangered species.”
Outline

➢ Part I: RESEARCH FOUNDATION, EVOLUTION, AND CHALLENGES

➢ Part II: ESSENTIAL ELEMENTS OF GREAT RESEARCH
  ➢ What makes great research?
  ➢ What are common handicaps?
  ➢ What are hot future research topics?
Pillars of Research Excellence

Critical Thinking
Information Access
Resource Access
Sharp Intuition
Vision & Roadmap
Communication & Marketing
Effective Advocacy
Courage to take risks

Problem-Solving
Field-Impacting
Common Handicaps to Research Excellence

- **Problem-finding:** Education focuses mostly on problem solving but in real world, it’s all about asking the right questions
  - A hard skill to teach and to measure, dominated by intuition
  - Aggravated when graduate students get problems from their advisors as thesis topics
- **Lack of vision:** Many researchers great at solving problems but lack ability to formulate a broadly-scoped vision for their field.
- **Inability to realize vision:** Even with a worthy vision in hand, researchers often unable to define and pursue a clear roadmap for its realization
Common Handicaps to Research Excellence

- **Poor communication of ideas**: Obscurity often encouraged and even rewarded
  - Education does not give enough priority

- **Complacency**: Keep working on the same kinds of problems, enjoying the ride not worrying about where you’re going

- **Fear**: to challenge deeply-held tenets of a field or disagree with intellectual giants
  - Leads to intellectual ossification, field in-breeding

- **Disregard for accountability**: As long as I have research funding, who cares whether my problems are really relevant or important?

- **Intellectual prejudice**: ideas not evaluated on merit alone; huge weight placed on researcher name and institution
Arrogance is a quality of a great researcher.

Arrogance fosters closed-mindedness, sets up professional barriers, and kills teamwork.
Common Handicaps to Research Excellence

Caving in under Competitive Pressures: When the going gets tough, compromising integrity may seem ok

- Hype might do the trick!
- Who said “borrowing” ideas is plagiarism?
- Recycling my own ideas is a great green initiative!
- Nobody will notice some missing data.
Most Overlooked Handicap to Research Excellence

Lack of diversity in personality types amongst research community!
Personality Profile of a “Typical” Researcher

- Male
- Highly Introverted (shown to be necessary attribute for creativity)
  - Happiest with few social interactions and deep thought
  - Social interactions and communication are draining
  - Prefers to work alone or in small teams
- Organized, productive, and decisive
- Creative, original, and independent
- Meticulous, cautious, and precise
Personality Profile of a “Typical” Researcher

**Engineers**

Sensate Thinkers dominate

- Driven by reason and logic
- Literal, realistic, practical, and observant
- Value hard work, service, responsibility, achievements

**Scientists**

Intuitive Thinkers or Feelers

- Driven by intuition
- Idealistic, visionary
- Value intelligence, knowledge, competence, ideas
Personality Profile of a “Typical” Researcher

Doesn’t sound like YOU??

CONGRATULATIONS!!
You have discovered you’re a minority in another dimension!
U.S. Research Landscape Today

- **Dwindling R&D funding:**
  - # of non-U.S. academic research conferences is growing
  - Investments in R&D by U.S. << Asia/Pacific companies since 1991
- **U.S. less relevant to global economy:** U.S. share of GDP declined steadily since 1999 from 22% of GDP to 19% in 2007 [Morgan Stanley]
- **Shortening research horizons:** as pressure to impact near-term future increases
  - Increasingly less basic research in academia and industry
  - [Read: “The decline of Unfettered Research”, Andrew Odlyzko, 1995]
- **Brain drain:**
  - Decreasing number of doctoral graduates staying in the U.S. post graduation
  - Many foreign researchers leaving industry to contribute to their country’s growing economy

U.S. loosing its competitive edge in science and technology: affects both academia and industry
Next Generation Research: Trends & Challenges

- **New era of open global intellectual competition**
  - Past research limited to elite with access to information
  - Barriers to information access dramatically reduced or eliminated
  - Innovation virtually open to everyone connected to Internet
  - Competitiveness tied to creativity and access to impact channels

- **Research driven by an improved understanding of social engineering and human psyche**
  - Highly responsive systems able to anticipate and adjust to human & society needs
  - Information query responses becoming very customized and context dependent with little human input (efficient secretaries)
  - Resource management techniques will follow social engineering cues (accurate demand prediction models for costly resources)
  - Devices and future applications will appear natural to human psyche, learn preferences of users, anticipate user needs
Next Generation Research: Trends & Challenges

- **Sensors everywhere**, leading to data explosion and the need for information filtering breakthroughs
- **Information security and privacy**: getting tougher and more critical every day
- **Immersive communication technology**: anywhere, multi-party, spontaneous, better than face-to-face
- **Future global communication networking**: Internet evolution or overhaul?
- **Nascent era of biological computing**
  - Prediction that physical sciences will be replaced by biology as the keystone of scientific thought
  - Lazowska’s recent “Synthetic biology”: a good path for CS?
  - Many new computing technologies for quality-of-life enhancements
Hot Computing Research Topics

- **Self-managing systems**
  - Today’s technology operational expenses >>> capital expenses

- **Natural human-device interfaces**
  - Devices and apps are ever-more feature-rich, error-prone, confusing

- **Wireless: mobility and the emancipation from wires**
  - Power efficiency, multi-radios and access diversity, peer-to-peer technologies, etc.

- **Universal & cooperative information appliances:**
  - Today’s user-driven, special-purpose information gadgets replaced by appliances that communicate with each other to enable universal information access & control

- **Green computing technologies**
  - economic need, environmental need, regulatory requirements soon (e.g., low power routers)
Hot Topics from Lazowska’s List

➢ Sensor-driven science (eScience)
   ▪ Science which uses massive amounts of sensor data and computing to automatically discover new knowledge.
   ▪ Top priority here is the environment = the “next space race”.

➢ Empowering the developing world

➢ Harnessing parallelism for computational speed growth

➢ Personalized Education: adaptive tutoring systems

➢ Computer-augmented driving

➢ Content creation tools (for entertainment) that truly support human creativity
Research: An Essential Skill for Future Success

My prediction: Future information complexity will drive huge power gap between Thinkers and Non-Thinkers - those unable or unwilling to participate in the information society will be left behind
Outline

➢ Part I: RESEARCH FOUNDATION, EVOLUTION, AND CHALLENGES

➢ Part II: ESSENTIAL ELEMENTS OF GREAT RESEARCH

➢ Part III: KEYS TO PROFESSIONAL SUCCESS
   ❖ Tips for success
   ❖ Tough Challenges
     ❖ work/family balance, diversity issues
   ❖ Career Pitfalls
Top 10 Tips for Success as a Researcher

1. Know thyself
   - For any given research domain, there are many different types of valuable research
   - Your professional *enjoyment* and career *growth* will greatly depend on your choosing a role that has a strong affinity with your personality

2. Exploit your uniqueness
   - Know what makes you different from your peers
   - Leverage that uniqueness to seek new perspectives on important problems
Top 10 Tips for Success as a Researcher

3. Be willing to take risks

- Ultra-conservative thinkers are unlikely to have disruptive ideas
- Brilliant contributions often start out as huge failures
  - Aviation history
  - Ethernet
  - Postscript
  - Post-It Notes
Top 10 Tips for Success as a Researcher

4. Seek good career mentors

- Learn from other’s experiences:
  “Those who don’t know history are doomed to repeat it”.

- Best mentors not only teach but proactively enable career growth
Industry-Specific Tips for Success

5. Network, network, network
   - Always seek to learn from your peers what are hot issues and concerns in your field
   - Connect regularly with researchers well outside your domain to learn what’s the buzz in their research circles.

   “Anything that gives us new knowledge gives us an opportunity to be more rational.”
   Herbert Simon, 1978 Nobel Prize

6. Manage your time wisely
   “Being successful doesn’t make you manage time well...managing time well makes you successful.”
   Randy Pausch
Top 10 Tips for Success as a Researcher

7. Be a proactive planner
   - Always think about where you want to be 5-10 years from now and work on a roadmap today

8. Be flexible
   - Be ready to reinvent yourself every so many years
   - Change of scenery fosters creativity, excitement, and relevance

Example: Prof. Dan Siewiorek’s 10 year rule
9. Balance your research efforts wisely

- Quandary: Don’t put all your eggs in one basket but have a focused work agenda!
  
  Diversification $\propto$ your funding budget and seniority

- Research is like a financial investment: you need a diversified portfolio so that as the economy changes, you don’t end up broke

  Economy/finance = 
  \[(\text{impact opportunities})/\text{research}\]

“Be prepared. Luck is truly where preparation meets opportunity.”

Randy Pausch
Top 10 Tips for Success as a Researcher

10. Have courage!!

- Voice your well-founded ideas and opinions openly, even if they conflict with popularly held beliefs
  
  Arrogance != Courage

- Have the guts to be a positive agent of cultural change too
  
  - Challenge cultural, political, and social barriers to progress at your workplace
  
  - Become a new trend-setter
7 Habits of Highly Successful People

THE 7 HABITS OF HIGHLY SUCCESSFUL PEOPLE:

1. MAKE MONEY
2. MAKE SOME MORE MONEY
3. MAKE LOTS MORE MONEY
4. MAKE EVEN MORE MONEY
5. KEEP MAKING MONEY
6. DON’T STOP MAKING MONEY
7. REPEAT 1–7

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7 Habits of Highly Successful Researchers

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5. KEEP CREATING IDEAS
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7 Habits of Highly Successful Researchers

1. Be proactive
   - Never miss an opportunity for impact

2. Begin with the End In Mind
   - Start with a vision

3. Put First Things First
   - Prioritize efforts based on risk/value/reward

4. Think Win/Win
   - Teamwork without burning bridges

5. Seek to Understand First, then to be Understood

6. Synergize
   - Build relationships with intellectually influential peers

7. Sharpen the Saw
   - Sharpen your mind through selective recreation and balanced life

[Src: Stephen Covey’s book]
Industry-Specific Tips for Success

- **Impact the core of your company**
  - Beware of the pains of doing marginal-impacting research

- **Build strategic alliances**
  - Only way to garner resources and support
  - Both internal and external alliances needed

- **Secure management advocacy**
  - Conquer your management’s circle of influence
  - Keep yourself on management’s radar
  - Keep open communication lines
  - Be a team player (need to compromise personal agendas at critical times)
Industry-Specific Tips for Success

➢ Reach for low-hanging fruits along the way to realizing your vision
  ▪ Short-term research impacts are critical for long-term support

➢ Be flexible but not hasty
  ▪ Industry is highly dynamic: winds of change blow often and hard.
  ▪ Formulate a vision and stay the course long enough to produce something of value
    ▪ Many successful projects at Bell Labs have been black-listed at one period or another
Industry-Specific Tips for Success

➢ Be humble
  ▪ Industry has low tolerance for research arrogance
  ▪ One incidence of disrespect can burn bridges for whole research organizations

➢ Be a great communicator & teacher
  ▪ Unlike Academia, Industry community is highly heterogeneous in backgrounds, job function, and priorities regarding research
  ▪ Selling your ideas effectively is *critical*
Tough Challenges to Career Growth: Work/Family

Common Myths

- You can have it all!
  - Only true if your all = career

- I’ll have a life after reaching my next career milestone
  - There is NEVER a shortage of work to be done nor of pressure to do it
  - Researchers are driven and obsessive

“It's not about achieving your dreams but living your life. If you lead your life the right way the karma will take care of itself. The dreams will come to you.” Randy Pausch
Tough Challenges to Career Growth: Work/Family

Common Myths

➢ Taking a break or slowing down is professional suicide
  ▪ The world moves at a much slower pace than we really think it does
  ▪ Bipolar thinking is wrong! Career choices in research are much more than just unconditional stardom or death
  ▪ Creativity does not emerge out of sheer hard work but out of having fresh outlooks

➢ My family/life can wait, but work can’t
  ▪ A healthy family/life demands consistent dedication
  ▪ Parents: The responsibilities and rewards of parenting dwarf those of our intellectual pursuits. Don't be too busy to miss it!
Tough Challenges to Career Growth: Work/Family

Common Myths

- My peers and leaders will respect my personal space and health
  - Any real or perceived barriers to productivity are seen as bad mark on your success report card
  - Respect is earned when we promote and defend our individuality

- Work/Family Issues are a woman’s problem
  - Men are just as affected
Tough Challenges to Career Growth: Work/Family

YOU must set your OWN personal boundaries early in your career and consistently defend them!

YOU must be ready to compromise your path to professional stardom for a healthy life

There’s no optimal universal tradeoff: Everybody has their own value system and circumstances

BEWARE! Don't wait for permission to have a life. Pursue it, or loose it!
Tough Challenges to Career Growth: Minority Status

Gender: It’s Still a Man’s World

- Less than 20% all PhDs in U.S. CS/EE from 1998-2005 [NSF]
- Steady decline in number of women entering CS (less than 10% newest undergrads in many schools)

Many theories for the decline

- Change in early childhood influences
- Lack of role models
- Negative stereotyping

My own theory: Comparatively high risk, unclear rewards/impact value

- Work/family balance choices seen easier in other fields
- Unfairly high competitive overheads are huge turn-off
- Women support culture still very weak: assimilation of women into male culture instead of diversity appreciation
Tough Challenges to Career Growth: Minority Status

- **Race: Pool of Hispanics still tiny**
  - ~1% PhD’s granted to Hispanics in U.S./year
  - Hispanics + African Americans + Native-Americans ~ 3% PhDs in CS [2005-2006 Taulbee Survey]
  - Not enough critical mass to build a very effective support system

But enough to have impact in attracting and retaining more talent, if we find ways to work together!
Greatest Career Pitfalls

ACADEMIC RESEARCH
Become an idea-generating machine without regard for the potential value of the ideas to become transformational

INDUSTRY RESEARCH
Become so consumed with realizing an idea that you lose sight of its weaknesses or miss other greater opportunities for impact
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- **Part IV:** ROUND-UP
KEY MESSAGES

- We are at an inflexion point in human history: dependence on technology is now critical & irreversible
- As researchers, we are responsible not only to create new ideas, but to promote their positive use for the good of humanity
- The specific ways in which we pursue this impact will depend on who pays our salary
- Be courageous: don’t abandon basic research!
- Academia and industry have different horizons and driving forces, but at the core, a successful research career should point in the same direction: drive both understanding and innovation
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LET’S PLAY !!!