

# FUNDAMENTALS OF SCIENCE AND TECHNOLOGY PUBLIC POLICYMAKING

## **Class 3: The Organization of Innovation at the Personal, Face-To-Face Level**

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# INTRODUCTION – FUNDAMENTALS OF TECHNOLOGY DEVELOPMENT

- RECAP ---

- BACKGROUND FOR  
THIS CLASS

# Solow and Romer

# I. RECAP: ROLE OF TECHNOLOGY INNOVATION AND TALENT IN GROWTH

- What do we know about the nature of innovation in economic transformation? what are the causal factors in economic growth?

**Professor of Economics Robert Solow, MIT --**

## Solow's Basic Growth Theory:

- NOBEL PRIZE IN 1987; FIRST OF THE GROWTH ECONOMISTS
- ATTACKS CLASSICAL ECONOMICS GROWTH MODEL AS STATIC MODEL - BASED ON CAPITAL AND LABOR SUPPLY
- FOUND MORE THAN HALF OF U.S. ECONOMIC GROWTH WAS CREATED THROUGH TECHNOLOGICAL AND RELATED INNOVATION
- DYNAMIC MODEL – WE CAN CREATE GROWTH AND THEREFORE SOCIETAL WELLBEING BY FOSTERING INNOVATION
- DIRECT (OR EXPLICIT) INNOVATION FACTOR #1: R&D

**Professor of Economics Paul M. Romer, Stamford Univ.**

## Romer's Basic Growth Theory

- If economic growth occurs primarily through technological and related innovation,
- Then: the key factor behind that innovation is "HUMAN CAPITAL ENGAGED IN RESEARCH"
- Has a "Prospector Theory" of Innovation

## **SO: TWO KEY DIRECT OR EXPLICIT GROWTH FACTORS:**

- R&D THAT YIELDS TECH INNOVATION (Solow)
- TALENT ENGAGED IN R&D (Romer)
- THESE TWO ECONOMIC GROWTH FACTORS CREATE AN INNOVATION SYSTEM ---

# RECAP -- INDIRECT INNOVATION FACTORS

Note: also part of Innovation Systems are Indirect/Implicit Innovation Factors:

## INDIRECT FACTORS SET BY GOV'T:

- Fiscal/tax/monetary policy
- Trade policy
- Technology standards
- Technology transfer policies
- Gov't procurement (for mission agencies)
- Intellectual Property protection system
- Legal/Liability system
- Regulatory system (environment, health, safety, market solvency and market transparency, financial institutions, etc.)
- Accounting standards (via SEC through FASB)
- Export controls, ETC.

## INDIRECT FACTORS SET BY PRIVATE SECTOR:

- Investment Capital –
- angel,
- venture,
- IPO;s,
- equity, lending
- Markets
- Management & Management Organization, re: innovative and competitive quality of firms
- Talent Compensation/Reward, ETC.

## **II. RECAP: QUESTION: IS THERE A THIRD DIRECT/EXPLICIT INNOVATION FACTOR?**

- **ANSWER: ARGUABLY, YES -**
- **THE ORGANIZATION SCIENCE AND TECHNOLOGY –**
- **THE WAY THE R&D AND THE R&D TALENT COME TOGETHER IN AN INNOVATION SYSTEM**
- **ARGUABLY, INNOVATION ORGANIZATION OPERATES AT AT LEAST TWO LEVELS – THE INSTITUTIONAL LEVEL AND THE PERSONAL, FACE TO FACE LEVEL – WE WILL EXPLORE THESE IN SUCCESSION.**

# RECAP: Innovation Systems at the Institutional Level

- WW2 – Vannevar Bush heads OSRD and NRDC – science/tech is integrated
- Post-WW2 – Bush’s “Endless Frontier” – gov’t role is to fund basic research – pipeline model – segregation of research stages
- R&D are separated
- Plethora of agencies when NSF set up late
- Result – Legacy of disconnected science
- Note: No other nation organizes science this way

# NOW: Class III. Innovation Systems at the Personal Level – Great Groups

- People innovate not institutions.
- It's not only the process of creating connected science at the institutional level – what about at the personal level, the face to face level?
- Warren Bennis, "Organizing Genius" (1997) – writes about the rule sets for "great groups"
- Rosen – lessons on the invention process
- Let's review the organizing elements of US "great groups":
  - Edison at Menlo Park
  - [recap Vannevar Bush/Alfred Loomis at MIT's Rad Lab]
  - Oppenheimer at Los Alamos
  - The transistor team at Bell Labs
  - Robert Taylor and Xerox Parc and personal computing
  - Boyer and Swanson - Genetech and biotech
  - Craig Venter, NIH and the genome project
- But lessons of DEC for great group failure

# 1) The Industrial Revolution in Britain

(William Rosen, *The Most Powerful Idea in the World* (2010)) – Lessons on the Process of Invention:

- “The Intelligent Hand” (pp 35-39)
  - Immanuel Kant – the hand is a “window on the mind”
  - Charles Bell – “intelligent hand”
  - Gestalt theory/Usher (historian of invention) – visual patterns appear all at once not in components
  - DaVinci – art and invention combined – role of a picture in invention – visual art
  - Rosen: visual and tactile, mind (eye) and hand
  - Generations of inventors build on each other’s work

# 1) The Industrial Revolution, con't

- The “**Flash of Insight**” problem—pp. 115-134
  - Watt’s walk on the Green of Glasgow and the idea of condensation in steam power
  - Insights appear as effortless because they build on the hard work of prior knowledge
  - Anders Ericsson: “expert performance” model – time on task not talent alone – difference in being truly outstanding – music, medicine, chess
  - Michael Polanyi – learning by doing – tactile knowing:
    - Knowledge plus skills
  - Eric Kandel – experiences change brain chemistry

# 1) The Industrial Revolution, con't

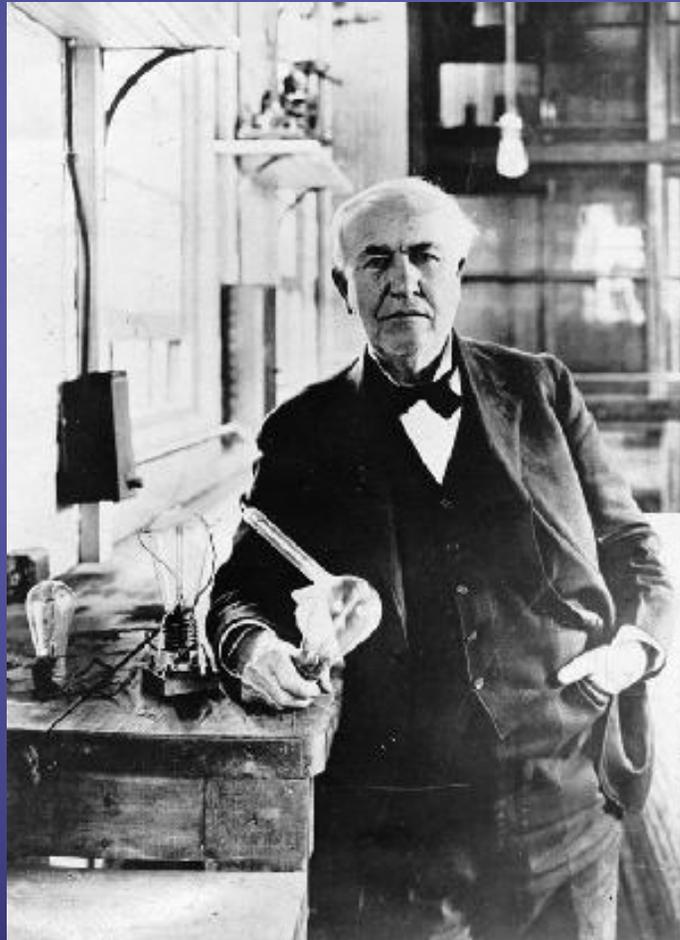
- Industrial Revolution in Britain – multigenerational – three generations:
  - Craftsmen – practical, limited training
  - Instrument Makers
  - Technical Learning – math background particularly important – joined with the practical
- John Smeaton – 18<sup>th</sup> century
  - Metrics for water flow under, over, past waterwheel
  - Systematically vary parameters via experimentation
  - Systematic process by which inventions can be tested

# The Industrial Revolution, con't

- Fritz Machlup –
  - Concept of the “knowledge economy”
  - Could you systematically expand the inventive workforce?
  - Key: supply of inventors [note: Romer – “human capital engaged in research”]
  - Make inventors heroes to encourage entry

## 2) Edison and the “Invention Factory” at Menlo Park

(from Harold Evans, *They Made America* (2004))



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## 2) Edison at Menlo Park

- Edison assembles dozen plus artisans and a few trained scientists at 100 foot wood frame building on his New Jersey farm – calls it his “Invention Factory”
- They work 24/7 – have pies at midnight, sing songs, recite poems - comraderie
- Invent the light bulb, but then have to invent whole electrical infrastructure – generators, public utility model, fire safety, wiring -
- Innovation requires a group (network?); invention, science frontier discovery don't
- Use Challenge Model – trying to solve specific challenge, goal, apply both practical and basic science to get there – Edison creates connected model tying invention to innovation – all stages
- Edison stands up non-hierarchical, relatively flat, 2-level, collaborative operation
- Mix of experimentalists and theorists, artisans and trained scientists/engineers
- Edison Effect – Edison has to derive electron theory to explain results – leads to atomic physics advances
- Lesson – science is not a linear pipeline going from basic to applied – it goes both ways: basic to applied and applied to basic – and have to have team that can collaborate in both ways
- Connection to deisionmakers/leaders - Edison goes to his Wall St. friends directly to get financing

*RECAP* - 3) Bush and Loomis  
and the Rad Lab at MIT

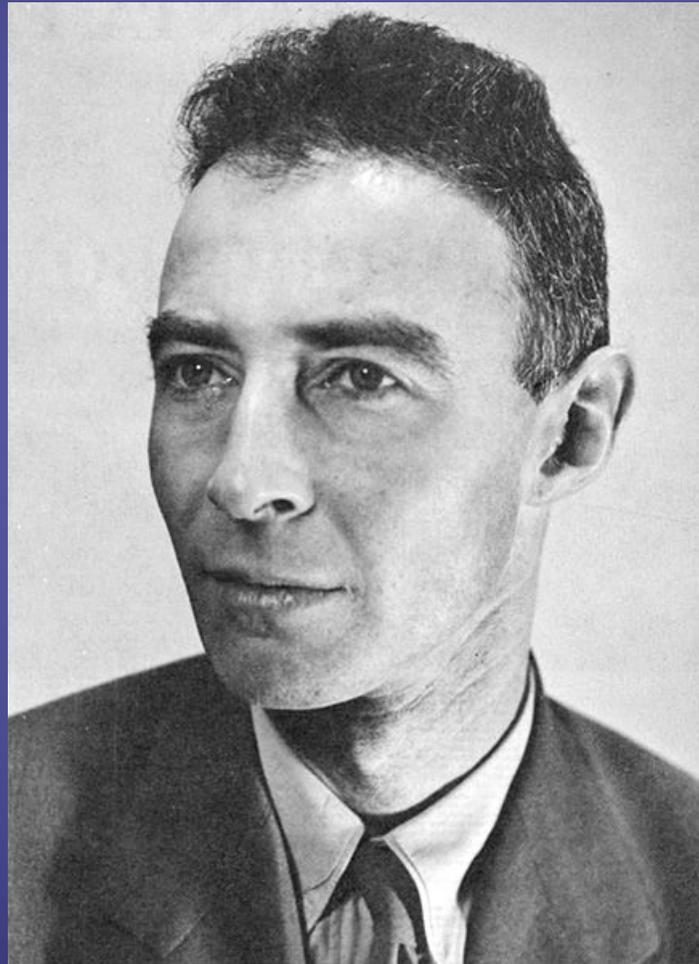
### 3) Vannevar Bush and Alfred Loomis and the Rad Lab At MIT– 1940-1945

- see discussion in: Jennet Conant, Tuxedo Park (2004), Pascal Zachary, The Endless Frontier (1997)
- Bush and Loomis mobilize science for FDR on the eve of WW2
- Bush – Engineering Dean at MIT, then heads Carnegie Institution in Wash., DC – becomes FDR’s science operative
- Loomis – loves science but becomes lawyer, leading Wall St financier for electric utilities in 20’s, sells out in ’28, sets up private lab at Tuxedo Park estate in 30’s for who’s who of pre-war physics
- Loomis’ field of study – microwave physics
- Bush centralizes science under “ONE TENT” – makes all the key organizational decisions -heads NACA then NDRC then OSRD
- Bush brings in Loomis, Sec. of War Stimson’s 1st cousin, to organize defense science
- Loomis stands up the Rad Lab at MIT – in weeks, after British hand over microwave radar to him at the Shoreham Hotel in DC

### 3) Con't – V. Bush and A.Loomis

- Loomis and his friend Ernest Lawrence of Berkeley call in the whole talent base of US physics into the Rad Lab
- Loomis personally funds it while gov't approvals are delayed
- Rad Lab – flat, non-hierarchical – project managers and teams, intense work around the clock, high spirits, purposely kept out of the military
- Develop microwave radar, proximity fuse – 11 Nobel prizewinners come out of Rad Lab, lays the foundations for modern US electronics
- Use Challenge Model – challenge based on fundamental breakthrough, connected to development, prototyping, and initial product market
- Both have the connection and authority to immediately go directly to the President and Sec. of War

## 4) Oppenheimer at Los Alamos



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# 4) Oppenheimer at Los Alamos

- (see discussion in: Martin Sherwin and Kai Bird, American Prometheus (2005); Jennet Conant, 109 East Palace (2005))
- Bush and Loomis work with FDR to stand up in '43--

## Review of organizational factors in Los Alamos model:

- Loomis' Rad Lab adopted as an organizational model for Los Alamos; approx. 10 leading Rad Lab scientists shifted to participate in Los Alamos, led by I.I. Rabi and Luis Alvarez – much of Rad Lab culture and organization transferred
- Military identity for scientists rejected – civilian non-bureaucratic status retained
- Weekly colloquiums for all to assure full participation and idea-sharing by all
- Flat organization, teams in two levels, democratic basis for exchange
- Cooperation and collaboration across team lines – shared knowledge base and full mindshare on problems
- Oppenheimer provides key leadership role – acts as a catalyst between teams and key researchers – bee spreading pollen

## 4) Oppy at Los Alamos, Con't

- Challenge model – group desperate to beat the Germans to the bomb – understood to be war-winning technology
- Quote from Sherwin and Bird: “Equally striking to Ulam as the cooperation was the conviviality, not only among the physicists, both theoretical and experimental, who differed greatly in temperament, but also among the mathematicians, chemists, and engineers. ‘People visited each other constantly at all hours after work,’ he wrote. ‘They considered not only the main problem – the construction of the atomic bomb and related physical questions about phenomena that would attend the explosion – the strictly project work – but also general questions about the nature of physics, the future of physics, the impact of nuclear experiments on technology of the future, and contrastingly its influence on the future development of theory.’ Beyond this there were wide-ranging discussions of the philosophy of science, and of course the world situation, from daily progress on the war fronts to the prospects of victory in the months to come. ‘The intellectual quality of so many interesting persons and their constantly together was unique. In the entire history of science there had never been anything even remotely approaching such a concentration.’”

## 4) Oppy at Los Alamos, Con't

- Drudgery can be transformed into sacrifice
- Richard Feynman: the technical team for security reasons is told to do endless calculations, but not why - slow and errors
- Oppenheimer overrules the Army and tells them what the mission is and what they will contribute
- “Complete transformation. They began to invent ways of doing it better. They improved the scheme. They worked at night; they didn't need anything. They understood everything; they invented several of the programs we used.” The work was done “nearly ten times as fast” once it had meaning.

5) Transistor Team at Bell Labs  
(Huddleston & Daitch, *True Genius* (2002))

## 5) Transistor Team at Bell Labs

- Bell Labs' Murray Hill facility is consciously modeled pre-war on Edison's Menlo Park, and postwar by AT&T's VP Mervin Kelly on the great military labs of WW2 – the Rad Lab and Los Alamos
- When Bardeen arrives at Murray Hill in '45 his first act is to sell his patent rights to AT&T for \$1 – “I really feel this is only fair. People can cooperate without worrying who is going to get the patent rights and this promotes a much freer exchange of ideas.” - Bardeen
- Mervin Kelly and Shockley want a solid state physics team of 50 scientists and technicians – emphasis on fundamental research but with an eye to practical applications

## 5) Con't - Transistor Team

- Bardeen and Brattain developed profoundly close collaboration – scientific skills and intuition of each matched each other – one outgoing, one reflective – families are social friends - deep mutual respect
- Backed up by AT&T's rich industrial technical support system, with latest equipment and tech staff support
- “magic month” – mid-Nov. to Dec. 16, 1947 – they develop first transistor
- Shockley, their supervisor who provided initial project definition, working in secret at his home adds key features [Semiconductor sandwich vs. elec. contact point], and tries to preempt patent
- Shockley's secrecy wrecks the trio's collaboration

## 5) Con't - Transistor Team

- Before Shockley breaks up the collaboration:
- True Genius, p. 127 - “The solid-state group divided up tasks: Brattain studied surface properties such as contact potential; Pearson looked at bulk properties such as the mobility of holes and electrons; and Gibney contributed his knowledge of the physical chemistry of surfaces. Bardeen and Shockley followed the work of all members, offering suggestions and conceptualizing the work. ‘It was probably one of the greatest research teams ever pulled together on a problem,’ said Brattain.”  
→→→

## 5) Con't - Transistor Team

- “I cannot overemphasize the rapport of this group. We would meet together to discuss important steps almost on the spur of the moment of an afternoon. We would discuss things freely. I think many of us had ideas in these discussion groups, one person’s remarks suggesting an idea to another. We went to the heart of many things during the existence of this group, and always when we got to the place where something needed to be done, experimental or theoretical, there was never any question as to who was the appropriate man in the group to do it” Brattain in Daitch and Huddelston, True Genius, pp. 127-128

## 6) Robert Taylor, Personal Computing & Xerox Parc

# Xerox Parc (Bennis & Biederman - 1997)

- Robert Taylor comes out of (D)ARPA where he funds computer research
- He leaves to head Xerox Parc, a new research center in Palo Alto
- Tasks are 4: 1) recruitment, 2) structure, 3)communications, 4) tools
- Task 1- hire great talent; that was Taylor's job at DARPA - "connoisseur of talent"
- DARPA's creed: "choose people over projects"
- Looks for collaborative talent, and hires people more talented than he is.
- Task 2 - Structure -Taylor's job - "managing creativity" - "get really great people together and manage the social dynamic" - Taylor studied this
- Have them sign up for "the duration" of the mission
- Structure: non-pyramidal, flat, no titles

# Xerox Parc, Con't

- Task 3 - Communications - You can't force the direction of a highpowered group - it will move to what is interesting
- Sharing info is crucial - weekly meeting (based on DARPA annual meetings) - share current research and let peers critique it - collective picture of the future of computing emerges
- Only one rule as Xerox Parc - you have to go to the weekly meeting and stay to end
- Everyone sits around on beanbag chairs
- Info gets shared interactively without memos and paper in social personal setting
- Taylor- "No organization works beyond the size you can get all the principals together in a room and thrash out the issues before you go home."

# Xerox Parc, Con't

- Task 4: Tools - have to have the right tools
- Access to cutting edge technology is crucial to great groups
- Rejects computer made by Xerox division Scientific Data Systems, and make their own, the “MAXC” after Max Palevsky
- Taylor is able to persuade “the suits” at Xerox to let him move ahead and get right tools
- Other things: Taylor has “religious zeal”
- Protects his PARC island - “Puts his body between Xerox and PARC”
- PARC is a “Learning environment”

# Xerox Parc, Con't

- Out of Xerox Parc:
- Dynabook - the laptop - idea from the 16th century, Aldus Manutius, the ideal book is portable and fits in a saddlebag - democratizes learning - interactive computer a child can use the size of a book
- Alto - the PC - Butler Lampson - interactive desktop with windows and the mouse (from Doug Engelbart)
- Playful - Cookie Monster is first image on machine - computing is fun not just big calculator
- Xerox decides not to develop any of this
- Steve Jobs of Apple visits for a day, see it and develops all of this at Apple - forces IBM to do PC
- “Creativity is just connecting things. When you ask creative people how they did something, they feel a little guilty because they didn't really *do* it, they just *saw* something. It seemed obvious to them after awhile. That's because they were able to connect experiences they's had and synthesize new things.” - - Steve Jobs

# Xerox Parc, Cont

- Bob Taylor's role as a leader:
- His "function was as a central switching station, monitoring the flow of ideas and work and keeping both going as smoothly as possible. And although he wasn't a computer scientist and couldn't actually do the work himself, Taylor's intermediary role made him so indispensable that it was always clear who worked for whom. Taylor was the boss. They called it Taylor's lab."; "Without Taylor there would have been chaos" - Robert Cringely
- Jack Goldman of Xerox who created PARC: "There are two ways of being creative. One can sing and dance. Or one can create an environment in which singers and dancers flourish."
- At PARC the team remembers it "as the time of their lives" - critical mass doing great things

7) Herbert Boyer & Robert Swanson, Genentech and biotech

# 7) Genentech/Boyer/ Swanson (from:

Harold Evans, *They Made America* (2004))

- Herb Boyer - from small town Pa., miner-railroader father, has a football coach (he's a guard) who interests him in biology and reads about DNA
- Studies at Pitt then Yale with time out for the civil rights movement
- His 2 Siamese Cats: Watson and Crick
- Robert Swanson - born in Brooklyn, raised in Florida; father was maintenance crew chief for Eastern Airlines
- Parents wanted to be sure he was the first in the family to go to college - one hour a week of TV
- Went to MIT - became unafraid of science - won chemistry prize
- Tackle things one at a time; manage your time

# Genentech, Con't

- Swanson goes to SF for job with Kleiner Perkins, first of the west coast VC's (Perkins is student of Doriot, Boston VC)
- He reads about genetic engineering, which Boyer is working on, to create hybrid molecules
- Public fears - Crichton's Andromeda Strain - NIH halts genetic engineering research in mid 70's
- K-P lays Swanson off - not interested in field
- Swanson starts cold calling biologists - gets to Boyer
- They have a beer at Churchill's and form a co. - metal sculpture at Genetech of this moment, guy in bellbottoms, guy in suit, with beers a table
- Goal: form co. to explore proteins that bacteria could be engineered to make
- Swanson first to see you can make a company quickly around basic medical research breakthroughs

# 7) Genentech, Con't

- Co. name is “Genentech” - genetic engineering technology
- Boyer - co. with commercial applications is way to “give something back” for years of gov’t research funding
- Swanson: look at yourself at 80 - look back at your past and what would you like to have accomplished? “I’m not going to like myself for not having given this a shot.” Lived on unemployment -- on a mission
- Project - make human insulin gene from scratch chemicals - synthetic DNA
- Build team of great researchers, with homes in research institutions
- K-P provides startup funds after somatostatin developed in ‘77 -inhibits growth, for gigantism

# Genentech, Con't

- Rent corner of a warehouse, t-shirts and sneakers, 14 hour days, vending machine for food, Italian researchers sings Neopolitan opera
- In a race with Harvard's great Wally Gilbert to - an enemy - winning underdogs
- Academic medicine contemptuous - corporate science could never clone a gene -- t-shirt at Genentech said "Clone or Die" - an enemy
- 8/23/78 - chemically synthesize genes for insulin - win race with two other teams forced to work in France Britain because of fears of NIH research limits
- Swanson schedules 9/6 press conf. to force his scientists to get their peer-reviewed article out -- Swanson sets splashy TV press conf. - Genentech is on the map

# Genentech, Con't

- Boyer is ostracized by academic establishment, works at UCSF
- Swanson runs the place, keeps hiring great talent, is inspirational
- Open unpretentious relaxed atmosphere; Caring for staff is a priority
- Breaks traditional secrecy of pharmas by allowing researchers to publish papers - attracts talent
- 1980 - Bayh Dole Act assures future of biotech's alliance with univ's
- Genentech and K-P develop stock options to attract & keep talent - device for sharing control, participation, common stake in ownership
- Attracts talent because mission: keeping people alive with breakthroughs - commercial model speeds breakthroughs vs. academic model - "you have to ship" - a more vital model; Swanson dies at 52

## 8) Craig Venter, NIH, Celera and the Genome

## 8) Craig Venter (Dan Morrow Interview (2003)), Con't

- Venter grows up in Milbrae, Calif., both parents ex-Marines, poor, competitive swimmer, almost flunked high school; rebellious
- After high school surfs off Newport Beach near “The Wedge”, boardwalk, volleyball, drinking, long hair, hotrod, lives in shack
- Threat of the draft, Vietnam War starts bigtime, goes into the Navy, bootcamp - still has a picture of his drill sgt. in his office
- Scores at the very top of the tests and picks medic training- finds out later this is the most dangerous job there is
- Goes to hospital in DaNang - runs intensive care ward - is there during Tet offensive in '68 - almost overrun- those who decide to live, live
- “Medicine failed us” - crude tools

## 8) Craig Venter, con't

- “Amputees and double amputees... because of all of the landmines. It was a failure of our political system. It was a failure of our knowledge of medicine and it was a failure even in some of these cases of psychological support for some of these guys. The whole thing was wrong and I became determined to change my life. I couldn't go back to just being a surfer - that I really loved what I was doing. I loved being able to change people's lives where I could...you try and take solace out of the ones you can help.”
- Worked at a village orphanage once a week.
- 12 hours on, 12 off for a year.
- Decides to become a doctor.
- Goes to junior college then college, UCSD.
- Then does science papers with mentor prof's.<sup>41</sup>

# Craig Venter, Con't

- PhD at UCSD with mentor prof. , then to Buffalo doing research and teaching
- NIH 1984, works with Marty Rodbell - molecular bio
- “Vietnam is something I carry with me everyday...the worst thing you had to lose was your life. So I basically viewed every day since I got back as a gift, and I was determined not to waste it or have it ruined by other people's small thinking. I figured what's the worst thing that can happen if I take a risk and fail? Whereas the rest of our structure is built on keeping people in place, because they're afraid to take risks. Every place I've succeeded it was from taking what weren't extraordinary risks.”
- Hears about Lee Hood's automated sequencing
- NIH rejects Venter's request for a sequencing machine, buys with with confidential DOD money

# Craig Venter, Con't

- Watson of NIH sees Venter's two gene neurotransmitter sequencing data developed over 10 years, and announces before Congress the next day that NIH leads the world and Venter's lab would sequence the human genome.
- Venter is forced because of his Institute affiliation to focus on neurology - NIH can't work across stovepipes
- Develops first bioinformatics because of need for computing power and new algorithms, then is able to quickly do 100's of new genes via "express sequencing tags" (EST)-thinks of on plane ride
- EST advance disrupts Watson's planning and budget - he attacks Venter for patenting the genome (note NIH patented first and the patent owned by the US) - NIH issue: the discovery is more important than the product; EST not accepted approach
- And NIH's Neurology Institute upset about broad application of Venter's work beyond neurology - outside stovepipe
- Venter leaves NIH with 12 on his team to set up own non-profit research institute funded by venture capital, tied to a separate for profit to develop results
- They link specific gene defects to colon cancer, publish results in *Nature* and *Science* and the race is on

# Craig Venter, Con't

- But high stress from VC-named CEO who wants to take credit for EST processing
- Venter meets researcher Hamilton Smith at a conf. and they develop “genome shotgun” method on sequencings not large clones but in pieces
- Article in *Science* makes this EST/shotgun technique clear to all - NIH concerned that an independent lab is undertaking the breakthroughs
- Dept. of Energy not NIH began genome funding because understood supercomputing power - first 3 genomes published with DOE funds
- Working with Perkin Elmer, Venter authorizes the then 3rd largest supercomputer (1.5 teraflops in 1999) to do “genome shotgun” - made by Compaq

# Craig Venter, Con't

- Venter negotiates a simultaneous announcement with NIH in 2002 of the genome in *Nature/Science*-what's the meaning?
- Francis Collins - we know something known before only to God
- Venter - "in reconciling things with those men in Vietnam, we try to understand life. We try to explain what it meant....answered by rigorous scientific efforts.
- Celera Genomics grew to \$14b market value then crashed in the dotcom crash; Venter was fired; now has foundation.
- The genome Venter published in 2002 is his own genome, with a mix of four other researchers.
- Venter: the power of the unreasonable and the insistent and the risk-taker
- Ideas are a dime a dozen; we'd have ten times the level of innovation if people were less afraid to pursue them - Venter
- "it takes brilliance to know how to execute, and it takes courage of conviction to be willing to do it." - Venter

# Warren Bennis, Patricia Ward Biederman, Organizing Genius (1997)

- Greatness starts with superb people
  - “You can’t pile together enough good people to make a great one” - Bob Taylor
- Great groups and great leaders create each other
  - Non-trivial problems require collective solutions
- Every great group requires a strong leader
  - A paradox of creative collaboration
  - the visionary’s dream occurs only if others are free to do great work
- Great group leaders love talent and find it
  - Leaders have to be confident enough to recruit people better than themselves

# Organizing Genius, Con't

- The talent in great groups can work together
  - Innovation requires collaboration, so must be talent for collaboration
- Great groups think they are on a mission from God
  - The zeal of converts, believers not doubters, followers of new truths
- People in great groups wear blinders - they only see their project
- Great groups are optimistic not realistic
  - Often young, they don't know their limits

# Organizing Genius, Con't

- Great Groups are Islands, but have a bridge to the mainland
  - To change the world you have to be isolated from it
  - Build your own culture, dress, jokes, language
  - Have to have fun
  - But have to have a reach back to resources that will enable follow-through
- Great groups see themselves as winning underdogs
  - For Apple, it's about beating Big Blue
- Great groups have an enemy
  - Manhattan project: the threat Nazi's will be first

# Organizing Genius, Con't

- In great groups, the right person is in the right job
  - Avoid Hollywood syndrome because the talent is more important than power
- Great groups give their talent what they need and free them for everything else
  - Feed the mission not the bureaucracy
  - Facilities should be what the mission needs not fancy
  - Information has to be in free flow among the group
  - The group needs protection from outside forces, esp. bureaucratic forces (“the suits”)
  - Zero dress code
  - Build morale - keep stress out - have fun
  - Tyranny destroys collaboration; it needs democracy and participation and respect

# SUMMARY FROM GREAT GROUPS:

- Teams are highly collaborative - right person doing the right job
- Flat, non-hierarchical and democratic
- Networked to the best thinking
- Use Challenge Model – you're on a MISSION
- Use Connected Science - fundamental science but breakthrough application in mind across basic, applied, prototype, development stages
- “you have to ship”-set real deadlines- competition
- Collect great talent, not just good talent
- Continuous info flow - collective ideas- principals have to fit in a room - group communication and networking is face to face
- Group has continuous learning environment

# SUMMARY FROM GREAT GROUPS, CON'T

- Leaders key for great groups - Oppenheimer: bee spreading pollen; Taylor: network connector, central processing unit
- Technology and fundamental research interact - basic to applied and vice versa - set that up with a mix in the group - theorists and tinkerers/experimentalists - need mindshare
- Comraderie, high morale, fun - it's play
- Connection to decisionmakers who can execute - Edison to Morgan, Loomis to Stimson, V.Bush to Hopkins/FDR, Venter to VC's, PARC's problem
- Los Alamos - "drudgery to sacrifice"
- Tools - cutting edge tools must surround group - why? Jobs- creativity is just seeing the connections

# SUMMARY FROM GREAT GROUPS, CON'T

- Have an enemy - Venter: Watson-NIH; Genentech: academic medicine; Apple: IBM; Los Alamos: Germany's Heisenberg; Rad Lab: win Battle of Britain, etc. - and be an underdog
- Let talent own the company - share in the endeavor, have a stake - stock options at Genentech
- Innovators are unreasonable troublemakers - Venter - Marine family, Vietnam vet, low end schools, misfit, rebel, a Wedge surfer at NIH - they have to break the box to achieve the mission

## 9) DEC (Edgar Schein, DEC is Dead Long Live DEC (2004))

- What happens after the innovation moment? How do great groups fail? How do you keep the group alive?
- DEC at the outset was a management culture less than a technological vision
  - Many great groups characteristics – relatively flat, collaborative, anti-hierarchy, diversity of talents, etc.
  - Open communications
  - Functional familiarity – shared experience
  - Limited large-scale management experience
  - Focus on empowered “problem solving” and “doing the right thing”

## 9) DEC is Dead, con't

- Early DEC technology/culture
  - Minicomputer not mainframe
  - Ken Olson, CEO – MIT, SAGE, Lincoln Lab
  - Obtained early VC funding from Gen. Dorrier of HBC – founder of entrepreneurship curriculum
  - Founded strong DEC culture of self-empowered innovation
  - By 1987, #2 computer co. in US
  - Bubble burst in 88-92
  - Initial innovation culture couldn't respond to next disruptive innovation shift

# DEC is Dead, con't

- 3 Paradigms in Computing:
  - Paradigm One – 1951-65
    - Mainframes, batch computing, IBM lead
  - Paradigm Two – 1965-81
    - Timeshared computing, minicomputers
    - DEC, HP, Wang
  - Paradigm Three – 81-now
    - Client-serving computing
    - Desktops, PCs, laptops
    - Workstations, servers, handhelds
    - Intel, Microsoft, Cisco, Oracle, Dell

# DEC is Dead, Con't

- DEC arose in the *creation* stage; missed the *dominant design* stage (Paradigm 3)
- DEC's downfall: interaction of technology, organization, culture
- Culture: loss of “functional familiarity”, of face-to-face management; “do the right thing” culture becomes harder to do, family becomes a clan
- Organization: distributed leadership, power of subunits and subcultures, strategic focus becomes harder
- Technology: core technology evolves, cost pressures grow with shift, inability of culture/organization to respond to tech shift

# CLOSING SUMMARY:

- Growth Economics posits two direct/explicit innovation factors:
- 1) R&D (Solow) and
- 2) S&T Talent (Romer)
  
- Is there a 3rd Direct/Explicit Innovation Factor?
- Arguably yes – the Organization of S&T – how you put together your R&D and Talent into a system
- Operates at Institutional and Personal Levels
- Looked at famous examples S&T organizational success for common threads:
- Menlo Park, Vannevar Bush's and Alfred Loomis' Rad Lab at MIT, Transistor team at Bell Labs, Xerox Parc, Genentech and the Genome Project
- Some of these are a reprise of the connected challenge models at Rad Lab – operating at the institutional and personal level

# Closing Summary, Con't

- These institutions are deeply collaborative, flat, feature close-knit talent, democratic, flexible, are oriented to breakthrough radical innovation
- They use a Challenge Model for R&D - move from fundamental back and forth with applied, connected to development, prototyping, and access to initial production
- Follow an innovation path not simply an invention path
- Like all human institutions, these organizational models are transitory
- Basic point: Innovation must operate at both the institutional and personal level
- Venter - innovation is not reasonable - breaks mold
- Review the rule set above - most important thing I can teach you

# Closing Summary, Con't

- DEC – when an innovation great group fails
  - Interaction of *core tech shift, culture, organization*
  - Initial creative culture can't cope with loss of face to face “functional familiarity”
  - Organizational structure not in place to manage the shift

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