

Characteristics of Successful Tech Hubs and Start-ups: Lessons from the Origin and Growth of Silicon Valley

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**Past Communications Director,
IEEE SF Bay Area Council**

**Entrepreneurship Hatchery,
University of Toronto,**

April 3, 2024



Paul Wesling received degrees in electrical engineering and materials science from Stanford University. He then worked locally at companies including Lenkurt Electric, Sperry-Univac, Datapoint Peripheral Products, and Amdahl, joining Tandem Computers in Cupertino in 1985. Paul retired from HP in 2001, then served as “Mr. IEEE” for the San Francisco Bay Area for 10 years. He is a Life Fellow of the IEEE.



As vice president of publications for the IEEE Electronics Packaging Society for 22 years, he supervised four archival journals and a newsletter. He received the IEEE’s Centennial Medal, the Board’s Distinguished Service award, the Society Contribution Award, and the IEEE’s Third Millennium Medal. An Eagle Scout, he served as scoutmaster of his local Boy Scout Troop for 15 years, was Advisor of a High-Adventure Crew, and enjoys backpacking, fly fishing, guitar and amateur radio (call sign: **KM6LH**).

Classic Silicon Valley: 1976

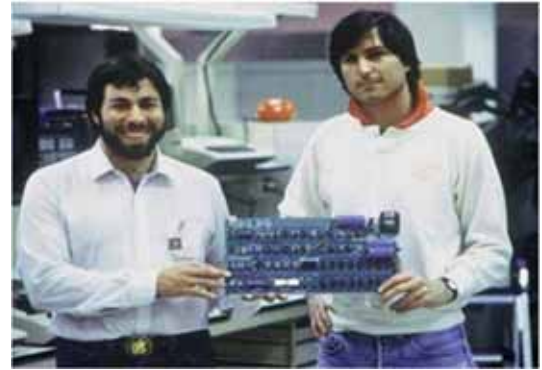
Homebrew Computer Club

- Hobbyists meeting in Menlo Park and at SLAC



6502 (US\$20)

- Steve Wozniak and Steve Jobs
- The Apple I (to sell to friends)
sold HP-65, VW Van



Neighbors; introduced by a friend

Classic Silicon Valley: 1976

- Wozniak-Jobs partnership
 - called it “Apple Computer Company”
 - Started in a **garage** in Los Altos
 - Now has largest stock market capitalization
 - Most **valuable brand** in the world



How could this happen?
Why in the SF Bay Area?



Here’s a hint:

- Steve Wozniak said, “Radio was a so important part of my life. **If I hadn’t been a ham**, I don’t know if I would have ever got to **Apple.**”

Keep this “hobby” focus in mind ...



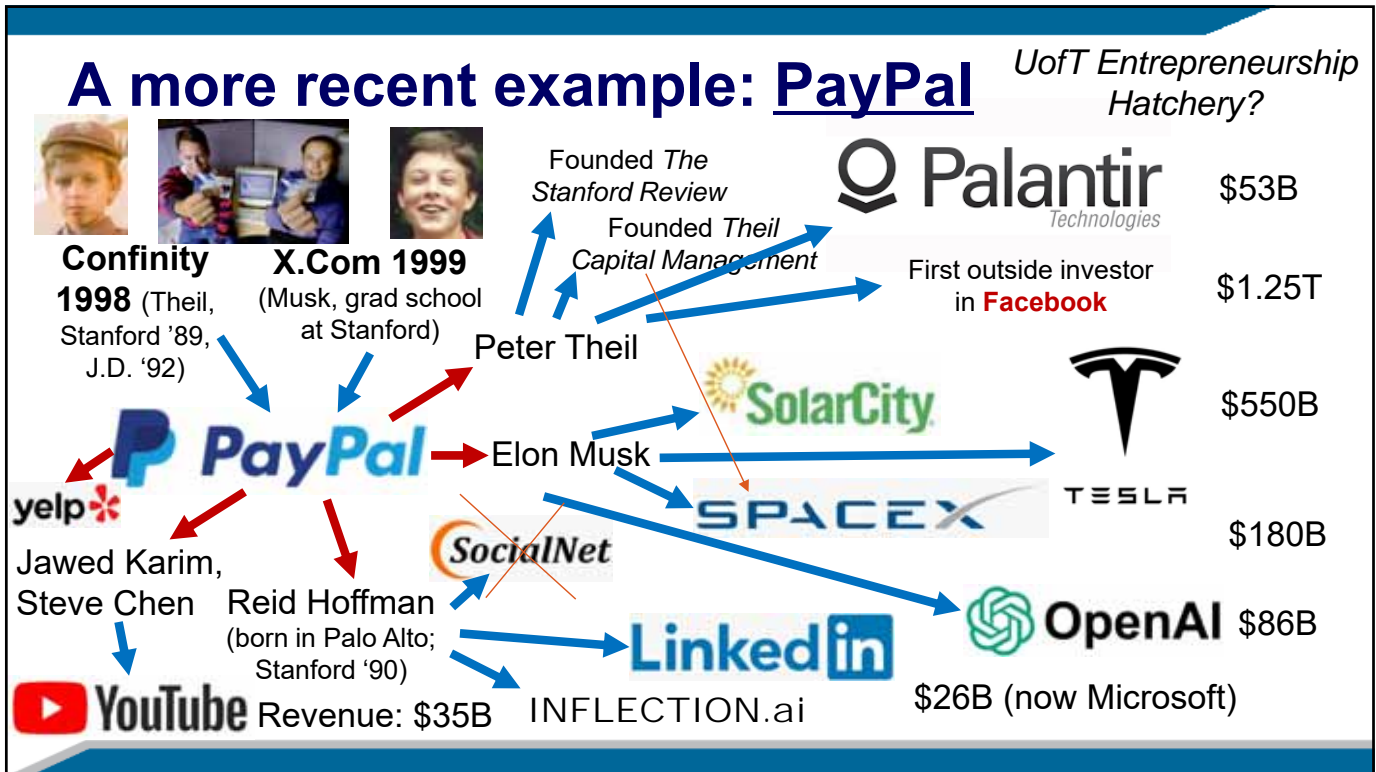
Steve “Woz” Wozniak with Paul at the WVARA meeting, March 2023

11 years old: built his first ham radio

A more recent example: PayPal

- Immigrants (Ukraine, Canada/So. Africa, Germany)
 - Started on the second floor of a Palo Alto bakery
 - Some were students/grads of Stanford
 - Names like Thiel, Musk, Levchin, Hoffman ...
 - Known now as the “PayPal Mafia”





Characteristics we will discuss:

- Competition *and* cooperation
- Often hobby-focused
- Small, dynamic companies
- Favorable California legal framework
- Great universities willing to engage with grads
- Large pools of entrepreneurs, technologists
-

Let's dig in!

Before 1900 ...

The Santa Clara Mission

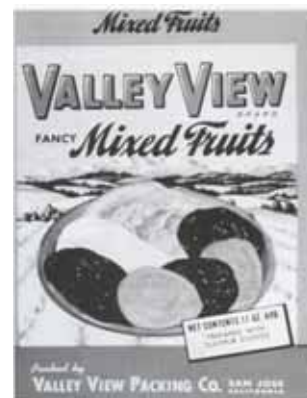


“Valley of the Heart’s Delight”



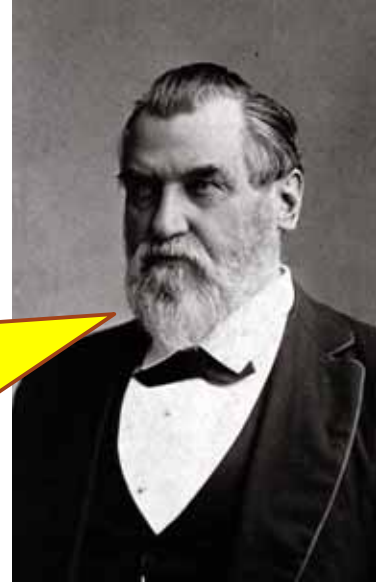
Before 1900

This was more typical ...



Late 1880's Prediction

“Some day you will see Palo Alto blooming with nearly all the flowers of the earth and the fruit and shade trees of every zone.... In the future we shall can this fruit and send it all over the globe in exchange for wealth ...”



Senator Leland Stanford

... but soon *technology* was to overtake agriculture.

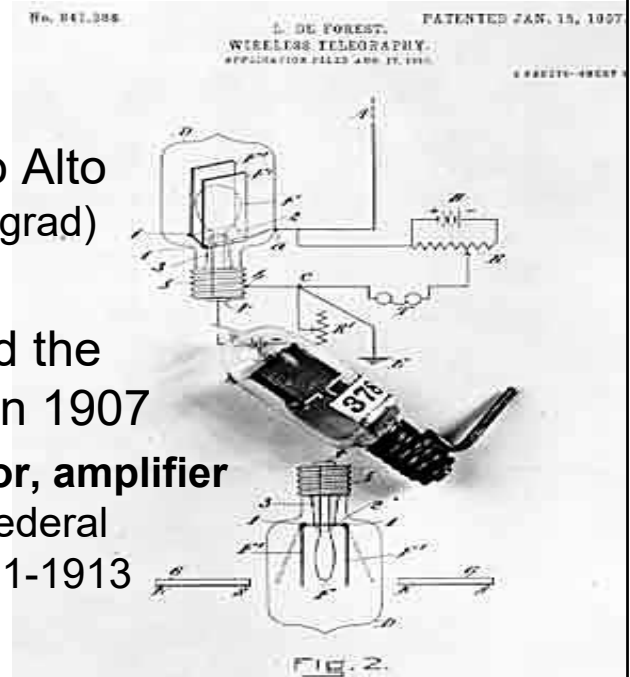
Let's Go Back ...

■ Federal Telegraph

- Formed in 1909 in Palo Alto (by Cyril Elwell, a Stanford grad)
- **Lee de Forest** invented the audion (vacuum tube) in 1907
- Invented/patented **oscillator, amplifier circuits** while working at Federal Telegraph in Palo Alto, 1911-1913



Improved triode



Federal Telegraph

- Poulsen Arc Transmitter, 1909
- Raised funds from “angel investors”, including David Starr Jordan, Stanford’s president (plus Marx, Branner)
- Demonstrated communication from S.F. to Honolulu in 1912 →
- **First “venture capital”**
- **Stanford’s Involvement**



Federal Telegraph

- By 1920s: three high-power stations that covered much of Pacific Ocean
- In support of maritime shipping companies
- California Historical Plaque in Palo Alto



Example: Early Roots of Entrepreneurial Technology

■ Otis Moorhead

- Early Stanford engineering grad
- Radio amateur & vacuum tube entrepreneur
- Established **Moorhead Laboratories**
 - In San Francisco in 1917
- Manufactured “bootleg” receiving tubes for radios
- A **patent-infringement lawsuit** put him out of business in the early 1920s.



Testing tubes, 1919

“Licensed for Amateur
Experimental Use
Only”

Defining Events

- Independent private **wealth**, from California gold rush
- Titanic Sinking in 1912
- World War I
 - Importance of **technology**
- US Navy “push” for ship-to-shore, other communications modes
- **Economics**: desire to replace expensive telegraph lines, undersea cables with the new “wireless” technology
- Brought frenzy of activity, funds to S.F. Bay Area



We Now Follow Three Pioneers

- **William Eitel**
- **Jack McCullough**
- **Charles Litton**
- Bay Area families
- Born/raised here



Charles Litton, 11,
Outside his
“Wireless House”

William Eitel

- Took shop classes at Los Gatos High School
- Worked in his father’s quarry
 - assisted as a blacksmith, machine operator
- Summer at Hall-Scott Motor Car Co.
 - Operation of Complex machinery

William Eitel
1908 - 1989



Bill Eitel in 1941 (Photo courtesy of
Dave Atkins, W6VX)

Jack McCullough, Charles Litton

- Attended **California School of Mechanical Arts**
James Lick funding -- Now Lick-Wilmerding High School, San Francisco (private)
- Opened in 1895; free education for boys, girls
 - Rigorous training in the mechanical trades
 - Gained "a realistic 'feel' of materials and processes" [Litton]

Jack McCullough
1908 - 1989



Jack McCullough, Charles Litton

- **McCullough** continued at a local junior college
- **Litton** enrolled in Stanford's Mechanical Engineering dept:
 - Classes with strong practical flavor
 - Got BS-Mechanical Engineering in 1924
 - Took Stanford's first course on communication engineering fundamentals

Eitel, Litton, and McCullough

- Introduced to **amateur “ham” radio** through their families and friends in 1910’s, ’20’s

- **Ham Radio in the SF Bay Area**
 - Isolated; maritime orientation; major seaport
 - Shipping companies needed radio operators
 - Over 1,200 licensed amateurs
 - **10 percent** of US total (a **bubble**)

Ham Radio in SF Bay Area

- Active center of radio production in the 1910s, ‘20s
- Electronics firms: Peter Jensen: brought from Denmark to SF by Cyril Elwell
 - **Magnavox** - leading manufacturer of loudspeakers
 - **Heintz and Kaufman** - Designed custom radio equipment
 - **Federal Telegraph** - Produced radio transmitters in the 1910s
 - up to 1,000,000-watt transmitters in 1920.
 - Radio parts available to **local hobbyists**
 - Jobs for radio amateurs

Ham Radio Subculture

- **Camaraderie** and sociability
 - A way to make friends
 - Communicating "over the air" and face to face
- **Egalitarianism** and a democratic ideology
 - little heed to **distinctions of class**, education
 - Santa Clara County radio club, which Eitel chaired in the mid 1920s, had “**farm boys, Stanford students, Federal Telegraph technicians, and retired executives**”

Ham Radio Subculture

- Interest in extending radio technology
 - Built personal reputations on improvements
 - Mix of **competitiveness** *and* **collaboration**

**A lot like the Home Brew Computer Club,
PayPal, and today’s Silicon Valley ...**

Another Pioneer: Young Fred Terman

- Los Angeles, then Stanford
- Herbert Hoover rented across the street;
HH Jr; also Roland Marx, George Branner, Jack Franklin

HH Jr: “All three of us [*Fred, Jack*] were neighbors, and upon pushing the key of one of our imposing contraptions, would holler out the window to see if it had been received on the other side of the street.”



Herbert Hoover, Jr, ca 1923

National Archives & Records Administration



HH, Jr, as ARRL president, 1963

Antique Wireless Association Journal

Young Fred Terman

- “If you saw a 90 foot pole sticking up somewhere, you’d go and knock on the door and get acquainted with him.”
- Hung out at Federal Telegraph (a few blocks away), then worked there one summer



Fred Terman at 17, with his Ham radio

Following our Hobbyists/Entrepreneurs

- Eitel, Litton, McCullough, ham friends
 - Experimented with **vacuum tubes**
 - Built their own parts, equipment
- Made notable contributions
 - 1924: Litton and the Stanford radio club made **first radio contact** with Australia, New Zealand
 - 1928: Eitel pioneered **10-meter waves** (30 MHz)
 - transcontinental communication

Following our Hobbyists/Entrepreneurs ...

- **Litton** got local job through a ham friend:

- Research at **Federal Telegraph**

- Built up to 60 engineers
- Became sole supplier of radios to IT&T

- **Eitel** got local job through ham friend:

- Mechanic at **Heintz and Kaufman Inc**

- Heintz W6RH was a ham -- focus on HF radio equipment

- Recruited **McCullough** a year later



Federal Telegraph
at Perham home,
916 Emerson St,
Palo Alto (1912)

The Tube Business

- General Electric, Westinghouse, AT&T
 - All East Coast companies
 - Developed hi-power transmitting tubes in the early 1920s
 - Difficulties in producing consistent, reliable ones
 - Required precise machining, glass blowing, exotic materials, sophisticated sealing techniques

The Tube Business in the '20s

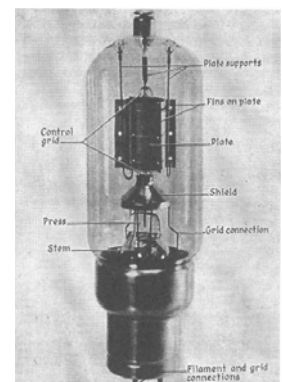
- Could not buy transmitting tubes on open market
 - Navy and GE set up **RCA** to ensure US dominance
 - RCA, GE, Western Electric, and Westinghouse
 - **Exclusive cross-licensing** of 2000 radio patents
 - Sole producers/distributors of power-grid tubes
 - Refused sale to Bay Area firms
 - Seen as threats to RCA, USA control
- So both companies needed to develop triode tubes
 - Litton, Eitel headed their tube shops

Tube Shops' Challenge

- Design around ~250 RCA patents
 - Enormously difficult task
- Hired locally (many were hams)
 - Eitel, Litton **collaborated** with each other (*novel!*)
 - Based on friendships over the years
- Worked closely with **patent attorneys**

Tube Shops' Challenges

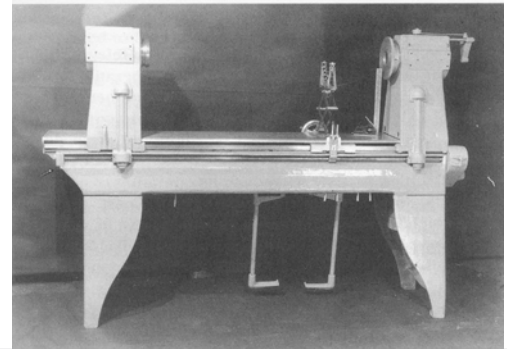
- Heintz, Eitel, and McCullough engineered a rugged **new** power tube:
 - New materials, manufacturing methods
 - New shock-resistant seals
 - Create higher vacuums (better reliability)
- More reliable, longer life than RCA's tubes
- **Didn't infringe RCA's patents**



Heintz and Kauffman
354 Power Triode Tube

Tube Shops' Challenge

- Litton **invented** the glass lathe
 - For assembly, glass blowing, and sealing
 - Make complex tubes in large quantities
 - High repeatability, precision
- Built tube shop on **parents' property**



The US Depression

- Formed Eitel-McCullough Inc (Eimac)
 - To build high-power, high-frequency tubes
- Financing:
 - Harrison: real-estate agent in San Bruno
 - Preddey: ran movie theaters in SF
 - Eitel and McCullough brought their know-how
 - Ownership, profits to be shared



Precursor to today's Menlo Park Venture-Capital Firms

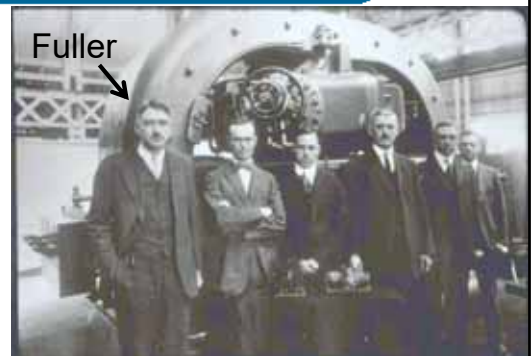
The US Depression

- Litton, Eitel, McCullough **cooperated** closely
 - Litton helped set up Eimac vacuum tube shop
 - Gave castings, engineering blueprints for lathe
 - **Freely exchanged** technical, commercial information
 - This reduced risks, for the two small tube-related businesses

**Like Jobs & Wozniak,
Homebrew Computer Club**

The US Depression

- Federal Telegraph in late 1920's
 - Leonard Fuller
 - Chief Engineer of Federal Telegraph
 - Stanford's first PhD in Electrical Engineering



- Federal Telegraph was sold, moved to East Coast
 - Left-over magnet for a 1MW transmitter donated by Fuller to UC-Berkeley, for Ernest Lawrence's 37" cyclotron
 - Enabled high-energy physics research, Nobel Prizes (Lawrence, McMillan, Seaborg, Chamberlain, Segrè, Glaser)

Ernest Lawrence's 37" Cyclotron



The US Depression

- 1936: **Frederick Terman** asked Litton to join Stanford EE dept as lecturer
 - Shared knowledge with staff, students
 - Sperry \$1,000 Litton klystron grant: let Terman bring **Packard** back to campus for grad studies
 - with Litton, Hewlett, others

- Formed Hewlett-Packard

Demonstrates University/Industry cooperation



Threats to Peace

- Growing threats from Japan and Germany
 - President Roosevelt rebuilt the Army, Navy
 - New electronic system: **RA**dio **D**etection **A**nd **R**anging (radar)
- Needed high-voltage high-frequency transmitting tubes
 - Only Eimac’s tubes worked best at the high voltages and frequencies needed



Eimac 50T

The Klystron

- Russell and Sigurd Varian
- They worried about Germany
 - Hoped to use microwaves to detect planes
 - 1937: Moved to Stanford’s labs to work with Hansen
 - developed the **klystron** in 1937
 - Used Litton’s free **advice**
 - Used Hansen’s theoretical assistance

Rus and Sig,
boys in Palo Alto



The Klystron – PA Times, Jan. 30, 1939



Wartime Expansion

- SF Bay Area/Stanford was microwave hotbed
- Developed a Progressive Approach to business
 - Egalitarian relations within, between companies
- Managerial techniques thwarted unions, kept employees happy, productive
 - **Profit-sharing**, tuition, cafeteria, medical clinics
 - “HP Way” philosophy

Similar to Hewlett-Packard, Fairchild, Intel, Tandem ...

Post-War Realignment

- RCA, others focused on TV, broadcast (NBC)
- Eimac developed new line of better tubes
 - Designed for higher frequencies (for hobbyists, hams)
- FCC’s surprise shift of **FM radio** to VHF (88-108 MHz)
 - RCA, others’ tubes **wouldn’t work** at VHF
 - RCA **copied** Eimac’s tubes, which **did** work

Reversal of Fortunes

- In 1947, Eimac sued RCA and GE
 - alleging patent **infringement**
 - GE, RCA lost lawsuit, halted production
 - Eimac transformed them into its own sales force and distribution network
 - Let them buy Eimac products and resell them under their own names

The “Big Dog” was now Silicon Valley!

Charles Litton After the War

- Focus on higher-power klystrons
 - For physics research, linear accelerators
 - Scaled from 30 **kilowatts** to 30 **megawatts**
 - Transformed Stanford into a major player
 - 2-mile-long linear accelerator: physics research
 - Cancer treatment today uses the Litton klystron



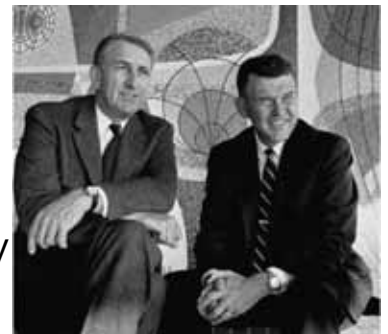
Varian Associates (another example)

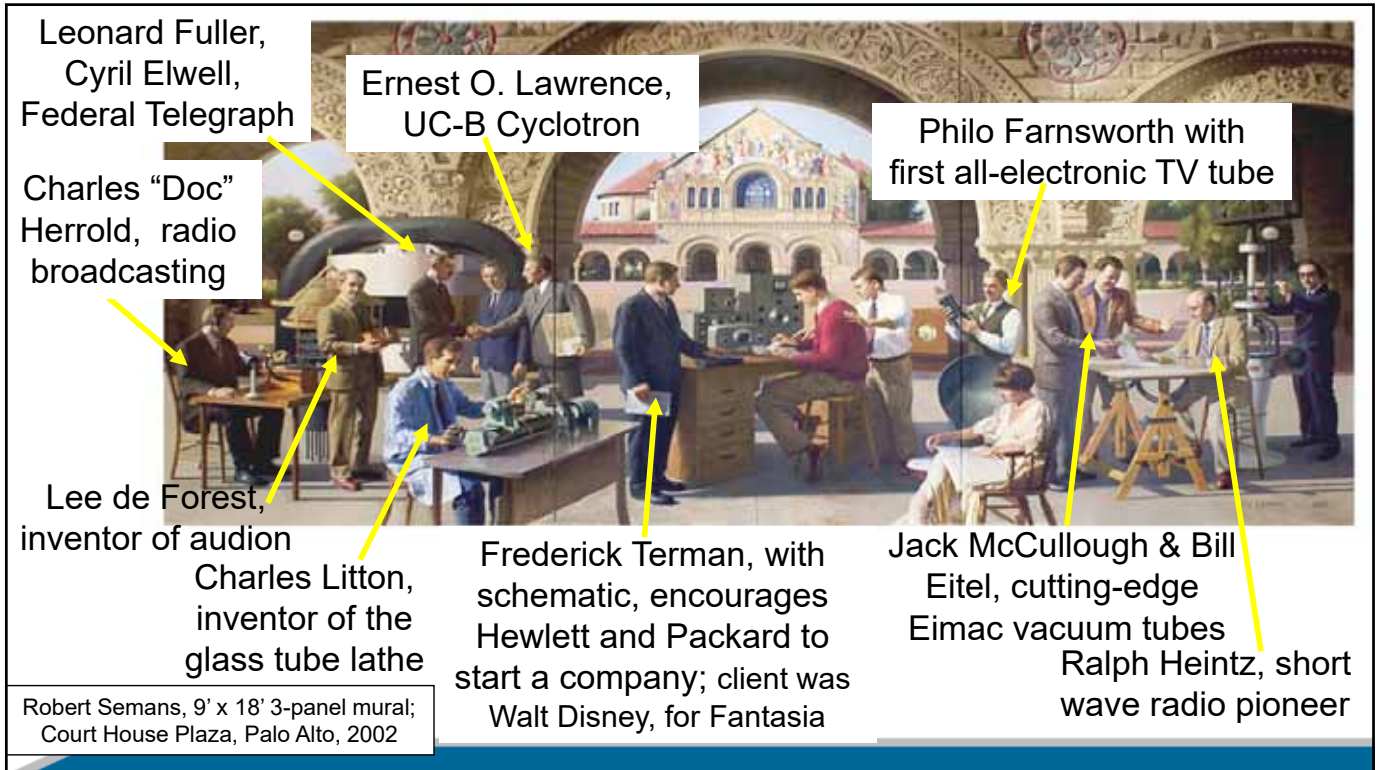
- 1948: Sold microwave measurement instrument plans to H-P for \$20,000
- Enabled Hewlett-Packard to enlarge its product line, increase revenues in 1950s
- Santa Rosa, Santa Clara divisions became Agilent (largest IPO in history), now Keysight



HP 200A Audio Oscillator

David Packard 9DRV
and Bill Hewlett





The Mural in Palo Alto



Fast Forward to 1950's

- William Shockley
Raised in Palo Alto;
went to Caltech, MIT
- Invented transistor
while at Bell Labs
- Developed to replace
vacuum tubes
- Nobel Prize in 1956
- “Silicon Valley” should have been in New Jersey ...



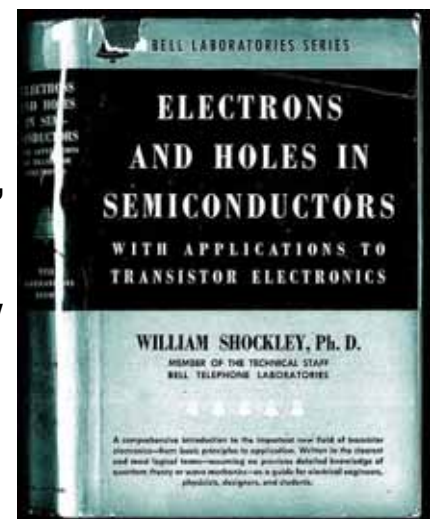
Bill Shockley, 8, in front
of home in Palo Alto



1948: William Shockley (seated),
John Bardeen, and Walter Brattain

Fast Forward to 1950's

- William Shockley left the East Coast,
returned to Caltech
 - Funding from Arnold Beckman
 - His mother, graduate of Stanford,
lived in Palo Alto
 - 1955: Shockley Transistor, Mt View
 - “Traitorous 8” **left** him in 1957 to
form **Fairchild**, with first real
venture capital funding



The Planar Process

- Needed, for diffused transistors
- Required a special infrastructure:
 - **High-vacuum** technology
 - **Precise** furnaces
 - **Glass/quartz capability** and machinists
 - Ultra-pure gasses/water
- **Process control**; continuous improvement



Jack Kilby, Nobel Prize:
co-invented the
integrated circuit



Jean Hoerni

**The IC: built on all of the capabilities
developed here during the '20's, 30's, '40's**

Courtesy Texas Instruments

The Planar Process

Isaac Asimov said this was

"the most important moment since man
emerged as a life form"

... perhaps with a bit of exaggeration.



At the end ... (1960's)

- Situation had changed dramatically
- Peninsula, Valley was a major electronics center
- Dev't, production of tubes, Semiconductors, ICs
 - Half of the microwave tubes
 - In every advanced weapons, space system
 - In a wide range of industrial goods
- SV was central to the US defense effort and to the US manufacturing economy

Why?

Silicon Valley Business Climate

- **East's** large, vertically integrated firms
 - Focus: protecting current products, markets
 - Slow to adjust to technology, market changes
- **SV:** highly fragmented, **decentralized** structure
 - **Specialized** firms, nimble/flexible, **engineering-driven**
 - Dense regional **network** of small and medium-size firms that support each other; draw from large, trained common work force
 - **California** (since 1870s) doesn't enforce **non-compete clauses**
 - Only 5 US States have this (**Ontario**: Since 2022; NY Governor vetoed it)
 - Adapt **more rapidly** to change -- thrived in the new environment

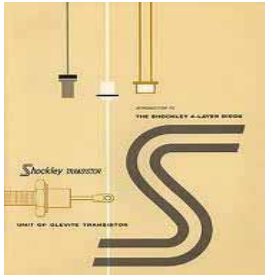
Silicon Valley Uniqueness

■ Practices, skills, and competencies:

- Developed over 100+ years
- Communities of hobbyists; collaboration/sharing
- Analog → digital → SW → biotech → Big Data
→ Deep Learning → VR → self-driving → ChatGPT ...
- Large number of cutting-edge entrepreneurs
- Supported by engineers and venture capitalists
- Local universities, research, development
- Supporting industries; Role models, expectations

Special Culture of Innovation

The '40's and '50's



AMPEX

FAIRCHILD
SEMICONDUCTOR®

hp HEWLETT®
PACKARD



SPACE SYSTEMS
LORAL

The '60's

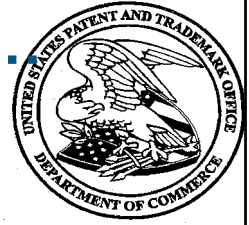


The '70's





Major companies have moved to SV ..



TOYOTA



JOHN DEERE

LABS



SF MOTORS

Chongqing Sokon Industry Group:
R&D Labs in Santa Clara



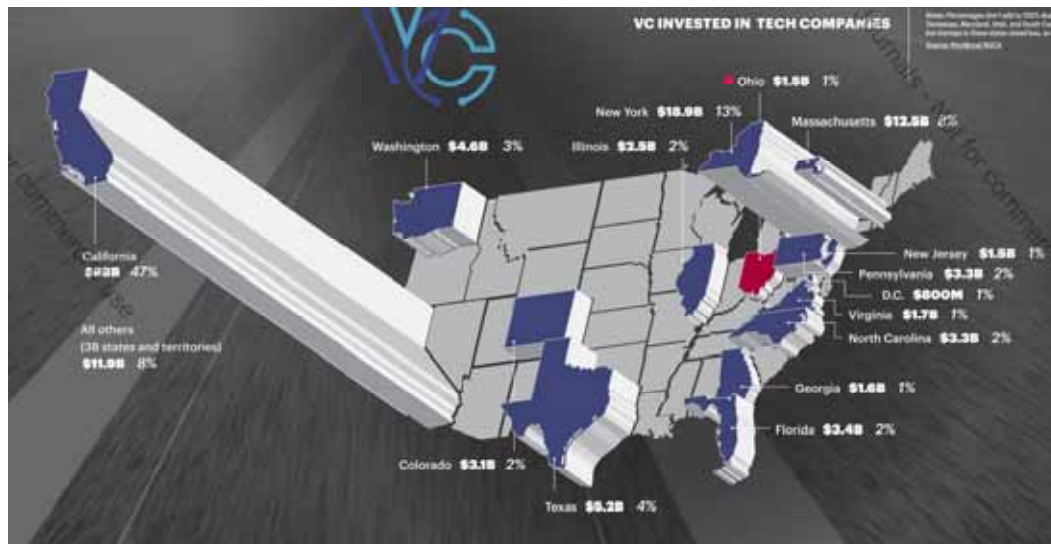
Where is “Silicon Valley”?

"A map of **Silicon Valley** in 2013, which originally just included the Santa Clara Valley from Gilroy to Palo Alto. Today it is a **metaphysical space** stretching from San Jose to San Francisco and Berkeley."

A History of Silicon Valley, p. 264



Where is VC funding?



First six months of 2022

(data from Pitchbook and National Data Venture Capital Association; source: C. Ghose, Columbus Business First; John Lauer)

How Different is Silicon Valley?

- Grass-roots innovation and initiative; bottom-up approach
- It's our **attitude** in Silicon Valley:
“**Failure** is a **feature**, not a bug.”
“Move Fast, Break Things”
- Yoda: “Do or do not — there is no *try*.”
– full commitment

Characteristics of SV: Ideas for your Tech Hub

- Competition *and* cooperation (not adversarial)
- Often hobby-focused (for start-ups with friends)
- Small, dynamic companies (work hard, play hard)
 - Avoid vertical integration like the plague
- Fluidity and flexibility (ability to “pivot”, fail, recycle)
- Egalitarian: parking, offices, “open door” policy, 20% time, Friday beer busts, employee-focus
- Ready venture capital and stock market
 - Demonstrated success percentage

Characteristics of SV: Ideas for your Tech Hub

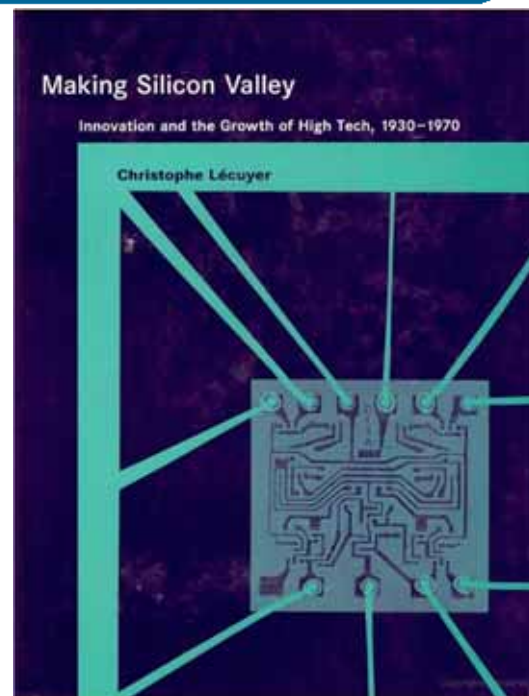
- Favorable California (and Ontario) legal framework
(*no enforcement of non-compete clauses*)
- A number of great universities: engage with startups
- Location attractive to educated professionals
- Large pools of entrepreneurs, technologists and opportunities (which attract additional techies)
 - **Network effect** (Metcalfe’s law: Influence \propto # of users squared)
- Energetic entrepreneurs from previous companies (successful, failed) available for next enterprise
- ... *and other cultural, management factors*

... and a few issues

- Cost of housing in SF Bay Area
 - “High-tech clusters tend to be located in cities with high labor and real estate costs — cities like San Francisco, Boston, or Seattle”
- Not enough educated technologists
- Resistance from existing business models
 - GovTech: accelerating pace, downsizing
- Retraining of displaced workers
- Shared-economy workers (ICs)

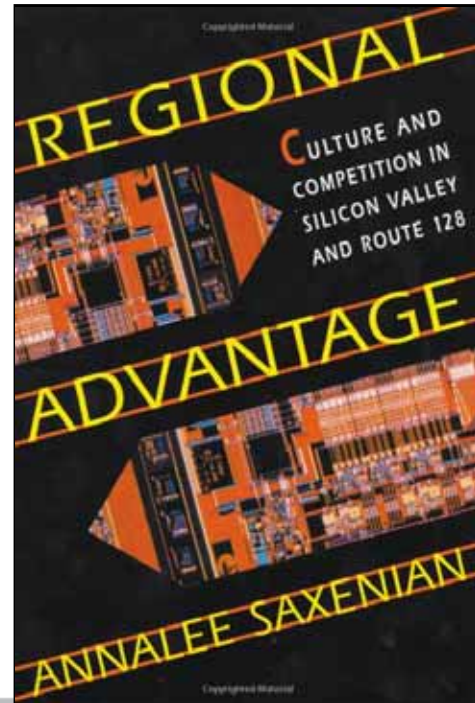
Get the book!

Learn MUCH more
about those early
days ...



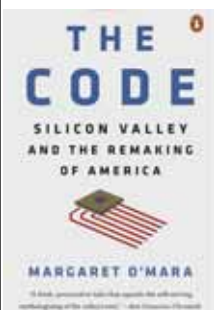
AnnaLee Saxenian’s book compares Silicon Valley to Boston’s Route 128...

professor at UC-Berkeley

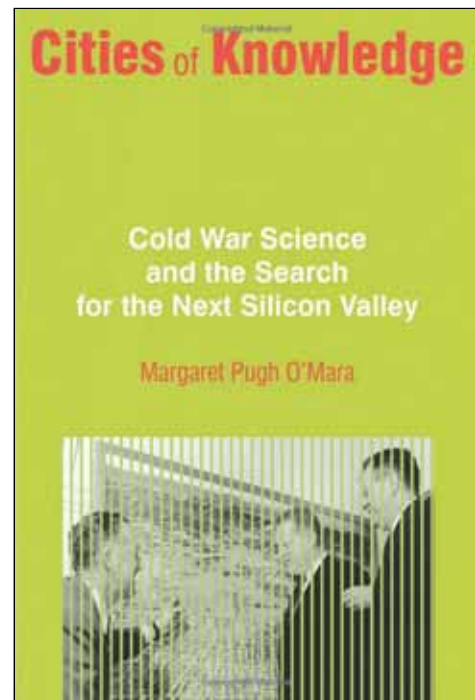


Margaret O’Mara’s book comparing tech areas around Stanford, U-Penn and GaTech...

professor of political, economic, and
metropolitan history



... and her new
book “The Code”



A good book for understanding how things work here, and ideas for duplicating the Valley in other places.

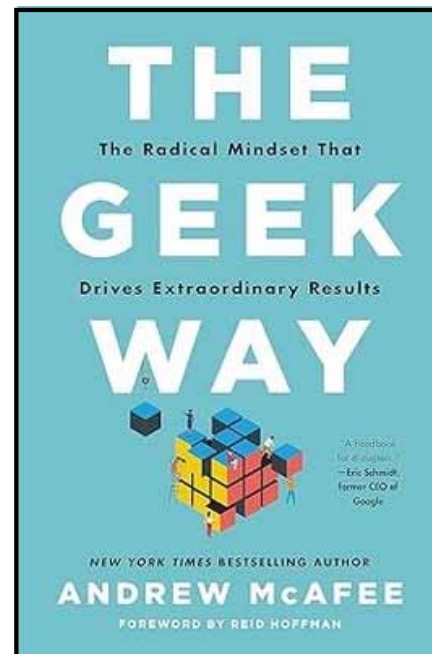
**2016, soft- or hard-cover,
ISBN 978-0-9973624-0-4**



A good book for understanding the tech leader mindset (2023)



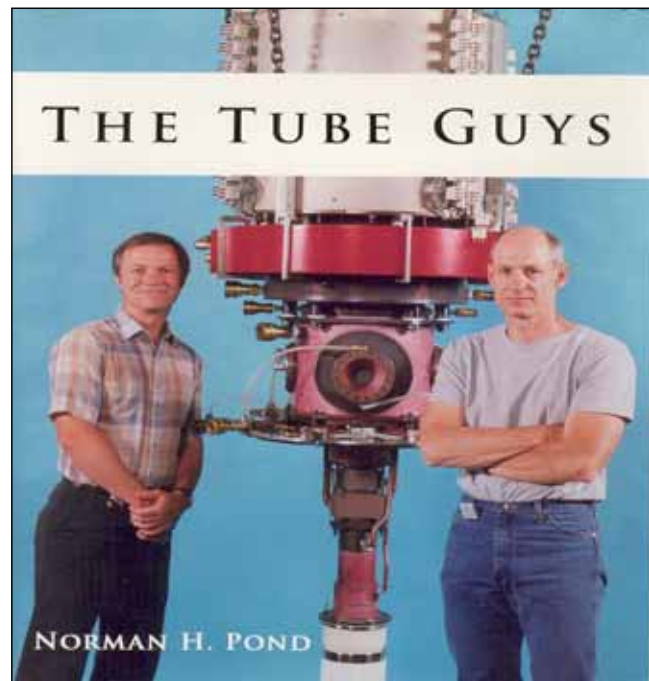
Paul with Andy McAfee, 2023



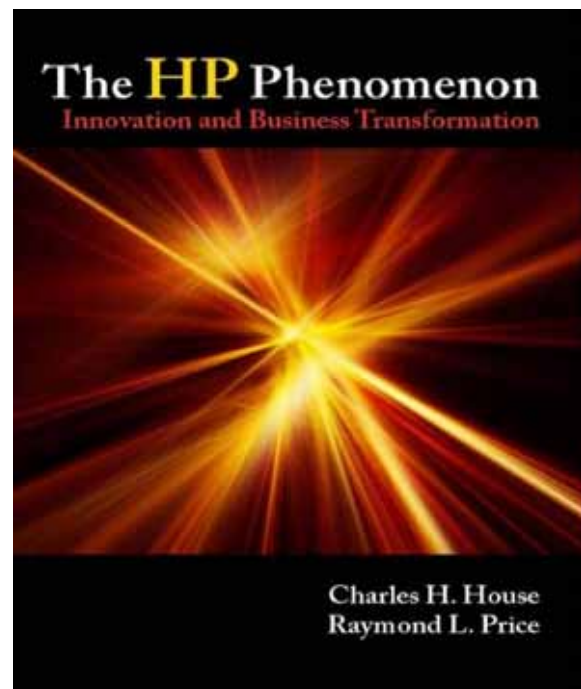
Another fun book

**Norm Pond was president of
Varian Associates (*Sigurd
and Russell’s company*), then
formed Intevac and is CEO**

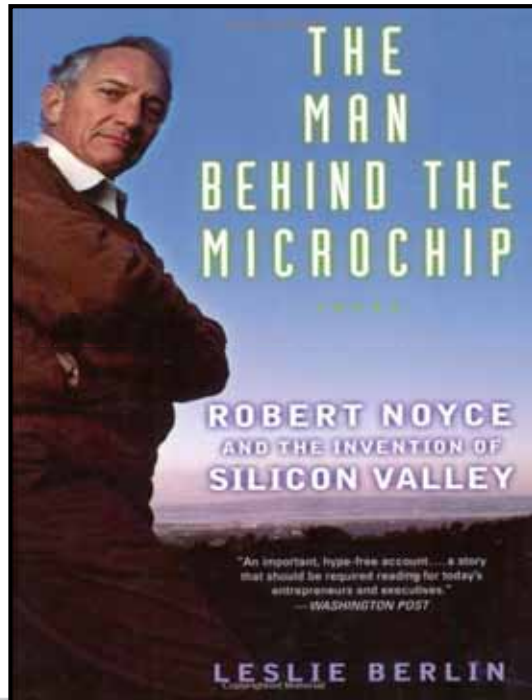
2008,
ISBN 978-0-9816923-0-2
www.russcochran.com



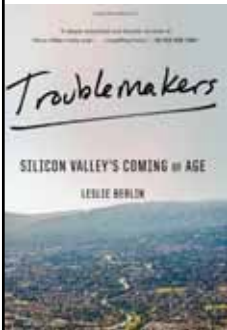
**To understand how H-P
was a product of
Silicon Valley, and
shaped its culture
through a number of
re-inventions
(1930s, up
through 2009)**



I also recommend Leslie Berlin’s book on Bob Noyce...



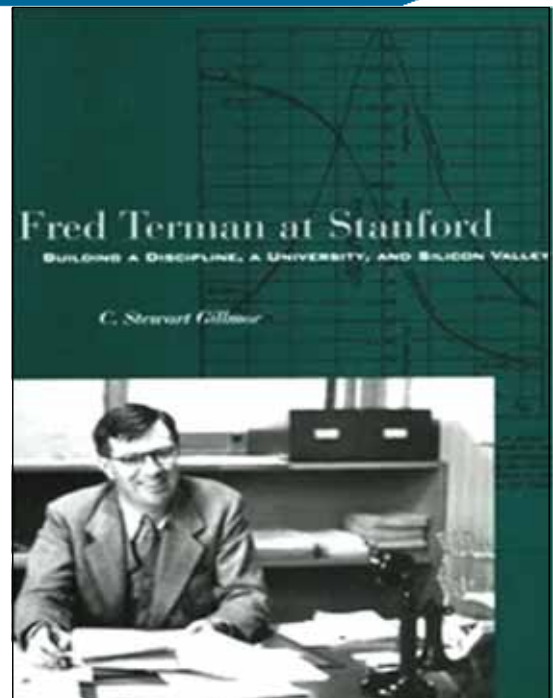
and her new book “Troublemakers”



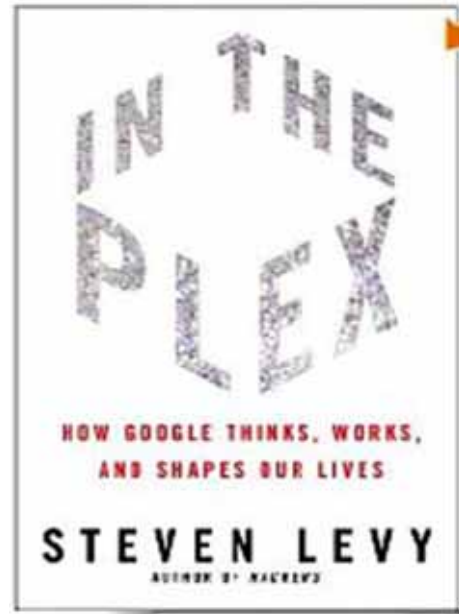
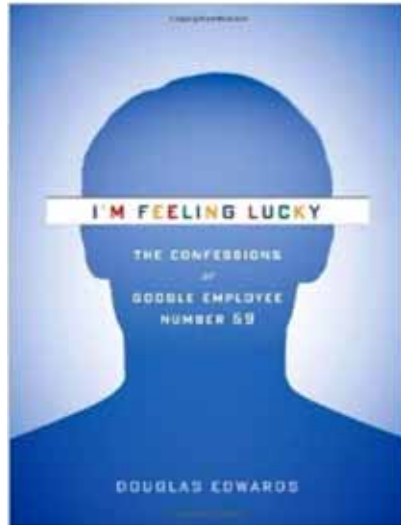
More about that period ...

**Fred Terman at Stanford:
Building a Discipline,
a University, and Silicon Valley
by Stewart Gillmor**

2004, ISBN 978-0804749145



For a view of another Innovation Environment



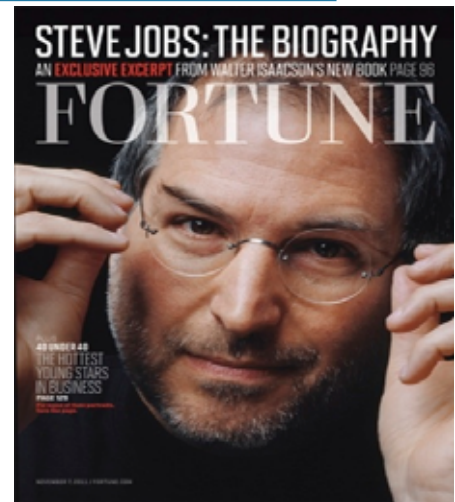
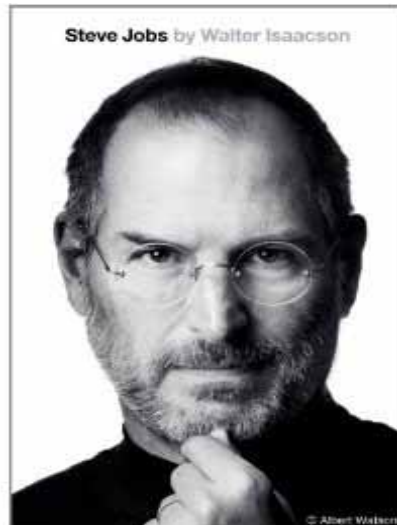
On Streaming (various services):

2011 video, 85 minutes
(SXSW Best Documentary)

Covers funding and startup of
Apple, Intel, Cisco, Tandem,
Genentech, with views from the
key funders (Rock, Perkins ...)
and entrepreneurs (Moore,
Lerner, Treybig ...)



For another view of Silicon Valley



Understanding Tech's Primary Hub ... how Silicon Valley became the center of technology development ... *and STAYS that way* ...

Download the slides and reading list (2 MB) at:

pwesling.com/docs/2404-ut.pdf

Video: *“The Origins of Silicon Valley”*

– Stanford's YouTube Channel: goo.gl/cSdSUH (38,000 views)

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