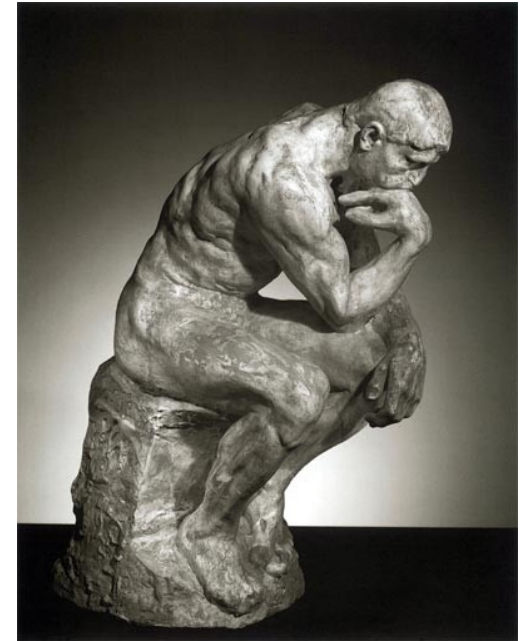
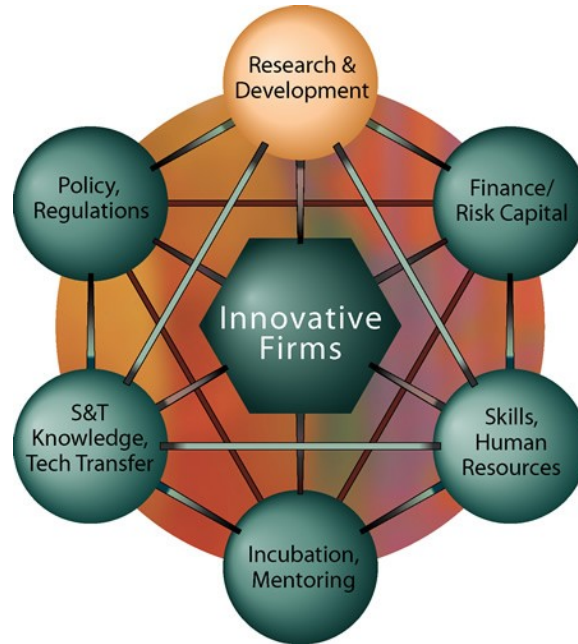


# TECHNOLOGY INNOVATION

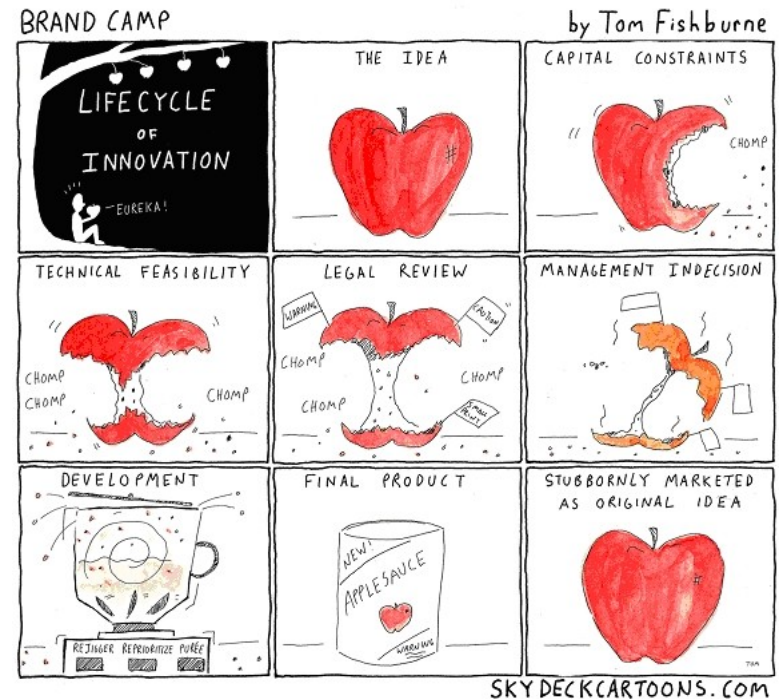
By  
Dr. Robert Finkelstein

(Based On: **Mastering The Dynamics of Innovation** by James M. Utterback)



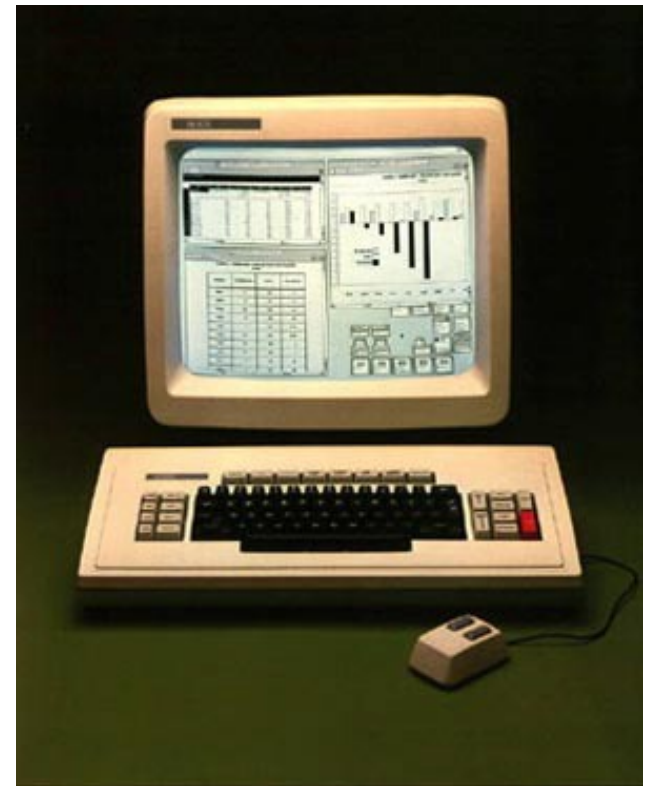
# INNOVATION: A DEFINITION

- **Innovation: transforming a new invention into a successful product (or process)**
  - **Creativity → Research & Development → Invention → Marketing → Product = Innovation**
- **Creativity: original behavior perceived to have value**
  - **Value (and thus the degree of creativity) is determined by experts or the public**
  - **Creativity (i.e., value) can be bestowed by experts or the public retroactively (e.g., Van Gogh's paintings, the laser)**



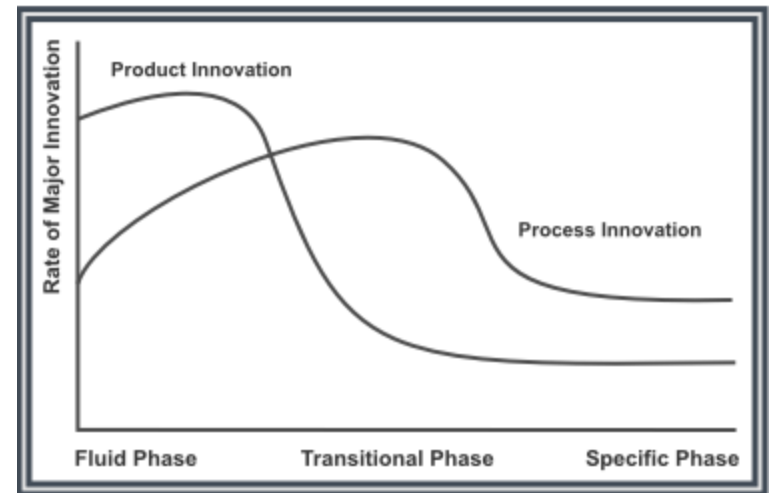
# INVENTION IS NOT INNOVATION

- Many great inventions are not turned into successful products by the original inventor
  - **Example: Xerox Palo Alto Research Center (Xerox PARC) invented the icon-based operating system (Graphic User Interface – GUI) in the 1970s, later stolen by Apple for Macintosh and then Microsoft for Windows (Xerox PARC was generally great at inventing and bad at innovating)**
  - **Apple sued Microsoft and Xerox PARC sued Apple for theft of intellectual property – lawsuits were dismissed because excessive time had passed**



# PRODUCT AND PROCESS INNOVATION

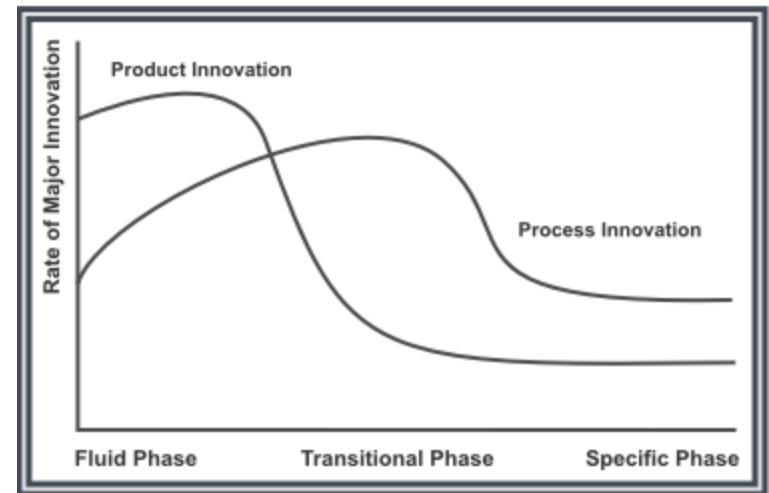
- **Abernathy-Utterback Model: for many industries, innovation for products & processes follow general pattern over time**
  - **In an industry or product class, innovation greatest in formative years (Fluid Phase)**
    - **Much competitive experimentation**
      - Like early automobile or aircraft industry (or animal evolution 650 million years ago)
      - Much product variety– many designs that fail
    - **Less attention (in Fluid Phase) to processes for production of the product class**
      - Rate of process innovation less rapid



Dynamics Of Innovation

# PRODUCT AND PROCESS INNOVATION

- **During Transition Phase, more attention to process innovation**
  - **Less product variety, more standard designs**
    - **Based on best engineering principles, or customer preference, or regulatory requirements**
  - **More efficient production, lower product cost**
- **During Specific Phase, only incremental product and process innovation**
  - **Focus on cost, volume, capacity**



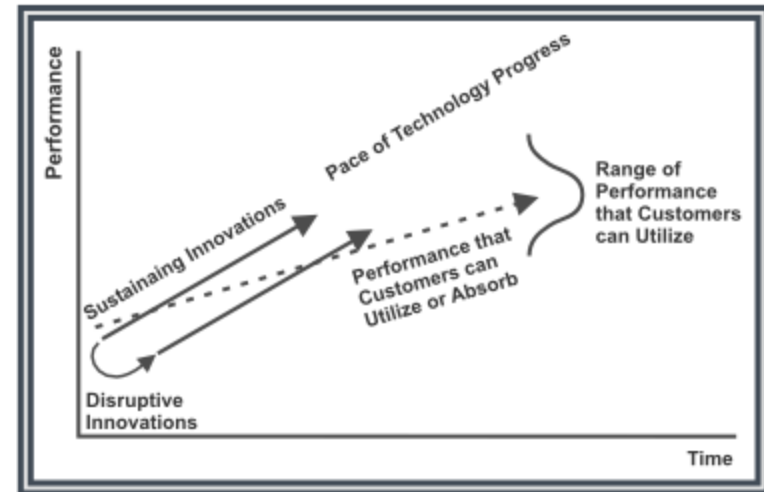
Dynamics Of Innovation

# CHARACTERISTICS OF THREE PHASES OF INNOVATION

CHARACTERISTIC/PHASE	FLUID	TRANSITIONAL	SPECIFIC
INNOVATION	Frequent major product changes	Major process changes required by rising demand	Incremental for product; cumulative improvements in productivity & quality
SOURCE OF INNOVATION	Industry pioneers; product users	Manufacturers; users	Often suppliers
PRODUCTS	Diverse designs, often customized	At least one product design sufficiently stable to have significant production volume	Mostly undifferentiated; standard products or commodities
PRODUCTION PROCESS	Flexible & inefficient, major changes easily accommodated	Becoming more rigid, with changes in major steps	Efficient, capital intensive, rigid; cost of change high
R&D	Focus unspecified because of much technical uncertainty	Focus on specific product features after dominant design emerges	Focus on incremental product technologies; emphasis on process technology
EQUIPMENT	General-purpose, requiring skilled labor	Some sub-processes automated	Special-purpose, mostly automatic; labor tends & monitors equipment
PLANT	Small-scale, located near user or source of innovation	General-purpose, with specialized sections	Large-scale, highly specific to particular products
PROCESS CHANGE COST	Low	Moderate	High
COMPETITORS	Few, but growing in numbers with widely fluctuating market shares	Many, but declining in numbers after emergence of dominant design	Few; oligopoly with stable market shares
BASIS OF COMPETITION	Functional product performance	Product variation; fitness for use	Price
ORGANIZATIONAL CONTROL	Informal & entrepreneurial	Project & task groups	Structure, rules, & goals
VULNERABILITIES OF INDUSTRY LEADERS	To imitators and patent challenges; to successful product breakthroughs	To more efficient and higher quality producers	To technical innovations leading to superior product substitutes

# DISRUPTIVE INNOVATION

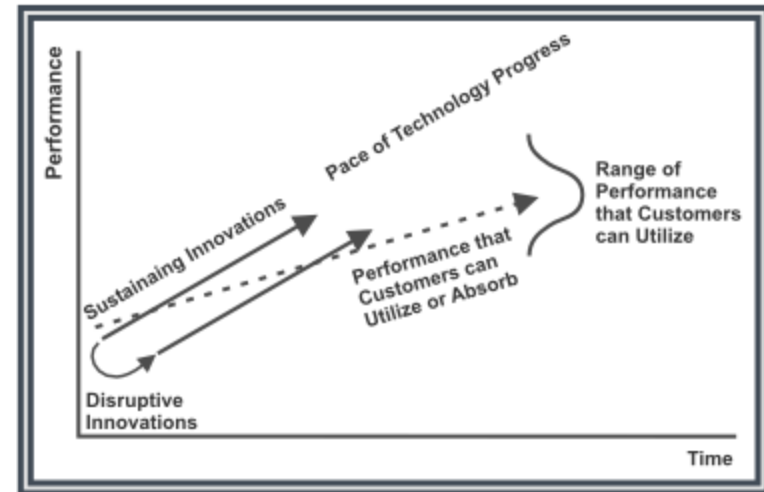
- **Disruptive Innovation Model**
  - Harvard Business School professor Clayton M. Christensen, *The Innovator's Dilemma* (1997))
- **Identifies three critical elements of disruption**
  - (1) In every market, there's a rate of improvement that customers can utilize or absorb, represented by the dotted line sloping gently upward across the chart
    - For simplicity, customers' ability to utilize improvement is depicted as a single line; in reality, there's a distribution of customers around this median - a range indicated by the distribution curve at the right
    - Customers in the highest or most demanding tiers may never be satisfied with the best that's available and those in the lowest or least demanding tiers can be over-satisfied with very little
    - Dotted line represents technology that's "good enough" to serve customers' needs



Disruptive Innovation Model

# DISRUPTIVE INNOVATION

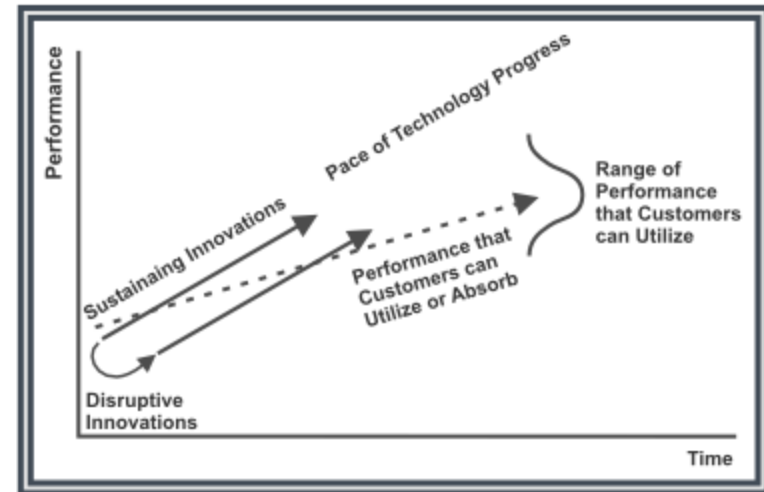
- **Three critical elements of disruption**
  - (2) In every market there's a distinctly different trajectory of improvement that companies provide as they introduce new and improved products
    - This pace of technological progress almost always outstrips the ability of customers in any given tier of the market to use it, as the more steeply sloping lines in the chart suggest
    - A company whose products are squarely positioned on mainstream customers' current needs today will probably overshoot what those same customers are able to utilize in the future
    - This happens because companies keep striving to make better products that they can sell for higher profit margins to not-yet-satisfied customers in more demanding tiers of the market



**Disruptive Innovation Model**

# DISRUPTIVE INNOVATION

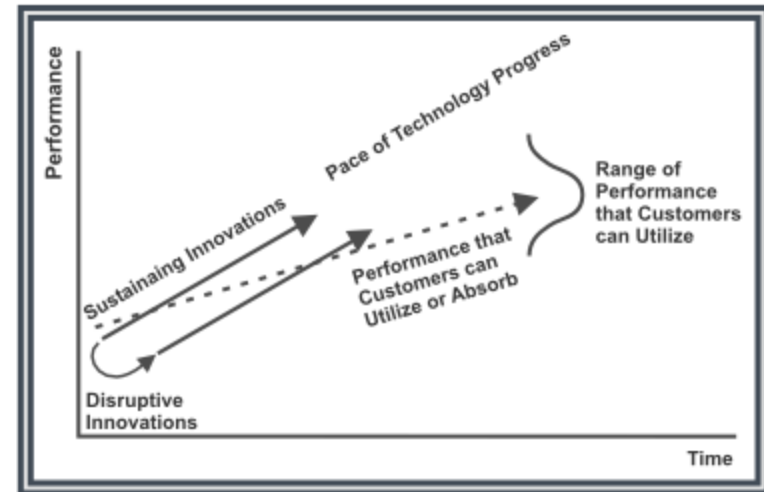
- **Three critical elements of disruption**
  - **(3) There is a distinction between sustaining and disruptive innovation**
    - **A sustaining innovation targets demanding, high-end customers with better performance than what was previously available**
    - **Some sustaining innovations are the incremental year-by-year improvements that all good companies produce**
    - **Other sustaining innovations are breakthrough, leapfrog-beyond-the-competition products**
    - **It doesn't matter how technologically difficult the innovation is, however: the established competitors almost always win the battles of sustaining technology**
    - **Because this strategy entails making a better product that they can sell for higher profit margins to their best customers, the established competitors have powerful motivations—and the resources—to fight and win sustaining battles**



**Disruptive Innovation Model**

# DISRUPTIVE INNOVATION

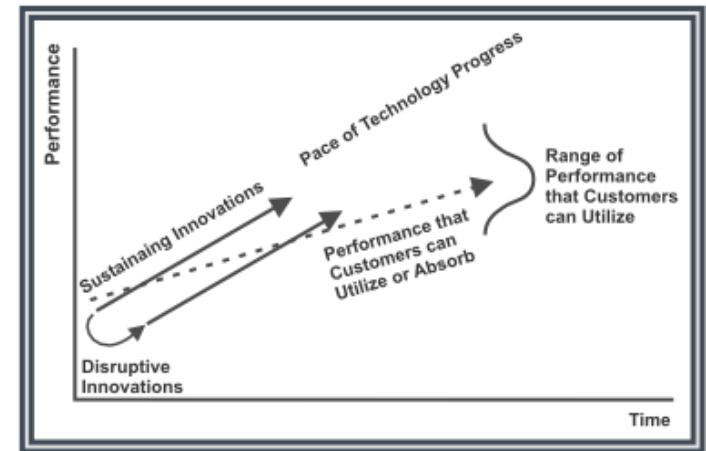
- (3) There is a distinction between sustaining and disruptive innovation (continued)
  - **Disruptive innovations, in contrast, usually don't attempt to bring better products to established customers in existing markets**
  - **Rather, they disrupt and redefine the competition by initially introducing products and services that are not as good as currently available products**
  - **But disruptive technologies offer other benefits - typically, they are simpler, more convenient and less expensive products that appeal to new or less-demanding customers**



Disruptive Innovation Model

# DISRUPTIVE INNOVATION

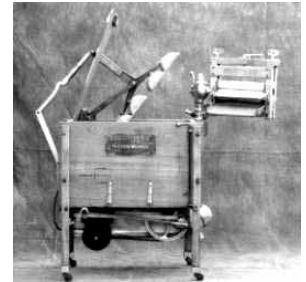
- (3) There is a distinction between sustaining and disruptive innovation (continued)
  - Once the disruptive product gains a foothold in new or low-end markets, the improvement cycle begins
  - Because the pace of technological progress outstrips customers' abilities to use it, the previously not-good-enough technology eventually improves enough to satisfy the needs of more demanding customers
    - When that happens, the disruptors can defeat the incumbents
  - This distinction is important for innovators seeking to create new-growth businesses: while current leaders of the industry almost always win in competitions of sustaining innovation, successful disruptions are usually launched by entrant companies



Disruptive Innovation Model

# TYPICAL INDUSTRY INNOVATION

- **New innovations usually based on older technologies**
  - **Components from various existing industries (e.g., displays, memory chips, sensors, fiber optics, servos, motors, etc.)**
- **Shifting ecology of firms**
  - **Initial innovator followed by multiplicity of competitors with various designs, followed by dominant competitor (perhaps not original innovator) followed by demise of many competitors followed by convergence and standardization of design (process similar to evolution)**
- **Waves of technological change**
  - **Over time, radically different technology is introduced to achieve the same function**
  - **New skills needed for production and users**



# TYPICAL INDUSTRY INNOVATION

- Changing leadership at breakpoints in technology
  - Disruptive (transformational) technology can cause industry leader (and other successful competitors) to fail and be replaced by new companies better able to exploit the new technology (e.g., electro-mechanical calculator companies Friden and Marchant were replaced by new purveyors - electronic calculator companies)
- Invasion of alien technology
  - New competitors often come from outside the old-line product industry
  - Old dominant companies flail about and cannot adapt to the disruptive technology and the new marketplace

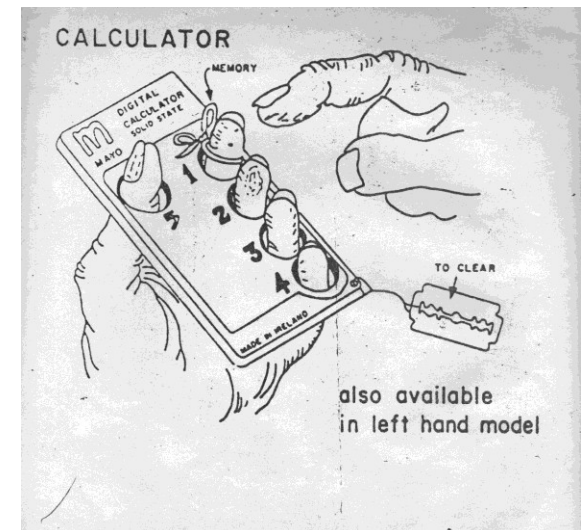
## MARCHANT turns man into SUPERMAN (and so simply)

A man multiplies himself at the keyboard of a Marchant — becomes man squared, man trebled, even man quintupled. No volume or complexity of figurework is too formidable for him. The Marchant, you see, is the world's fastest desk calculator, and its flexibility fits it for every type of problem. But, such is its advanced design that complicated calculating has been reduced to staggering simplicity. So even if you've got that man feeling sometimes you can still be a superman with a Marchant. There are models to match every modern need.



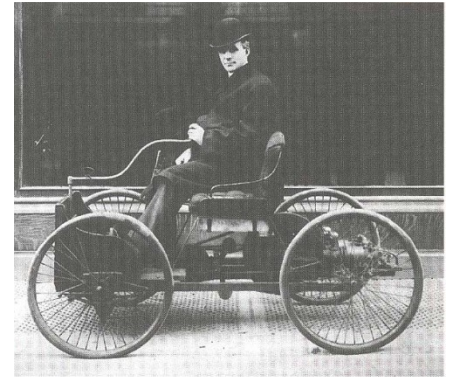
Free Booklet—"Modern Calculators in Business Today" explains fully the simplicity, speed and profitability of calculation by machine. For your copy—mail the coupon today!

## MARCHANT CALCULATORS



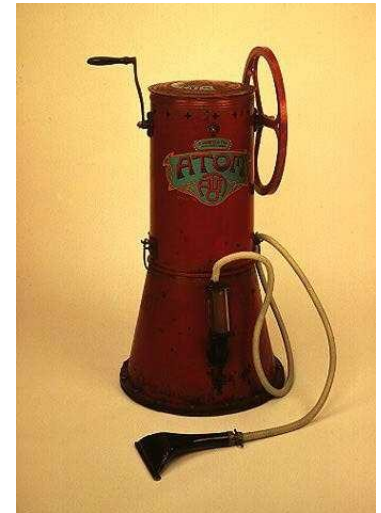
# INNOVATION: DOMINANT DESIGNS

- **Pioneering firm markets initial product**
  - **Market grows around that product**
  - **New competitors enter and expand market with new versions of product**
- **No firm has lock on market during embryonic stage of product**
  - **Product not perfected**
  - **No firm has mastered manufacturing process**
  - **No firm controls distribution channels**
  - **Customers haven't decided on ideal product design or desired features and functions**
  - **Market and industry fluid and learning with experience**
- **Embryonic stage conducive to new entrants**
  - **If capital and technology barriers not too high**
  - **Dominant design emerges from fervent experimentation and competition – ecology of market changes and many competitors fail**



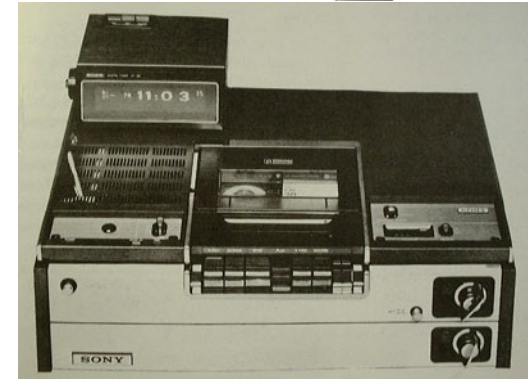
# INNOVATION: DOMINANT DESIGNS

- **Dominant design: a design in a product class that achieves overwhelming market acceptance**
  - **Competitors and innovators must emulate it for success in the marketplace**
  - **Often is a new product (or set of features) synthesized from technological variations introduced independently in prior product variants**
    - **Example: IBM Personal Computer**
  - **Meets the needs of most users – but not optimized as customized design for some users; satisficing (neologism by Herbert Simon: satisfying + sufficing), but not optimizing)**
  - **Not necessarily the best technology or product performance**
  - **Often incorporates in the product previously separate or optional features (e.g., windshield wipers in cars)**



# INNOVATION: DOMINANT DESIGNS

- Dominant design emerges from interaction of technology and market choices
- **Other factors:** collateral assets, industry regulation and government intervention, strategic maneuvering by individual firms, and communication between producers and users
  - **Collateral assets (or co-specialized assets)**
    - **Examples:** market channels, brand image, customer switching costs
  - **Industry regulation and government intervention**
    - **Examples:** FCC regulations for HDTV or DOT regulations for airbags & seatbelts in cars
  - **Strategic maneuvering at the firm level**
    - **Examples:** Betamax vs. VHS video cassette recorder standards; Apple vs. PC
  - **Communication between producers and users**
    - Close contact with users during experimentation; close ties to leading users, users' associations, and industry groups (e.g., new weapons systems)



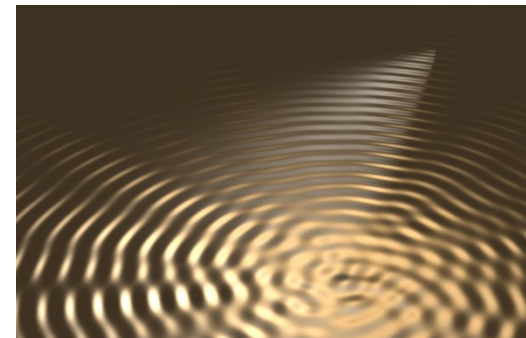
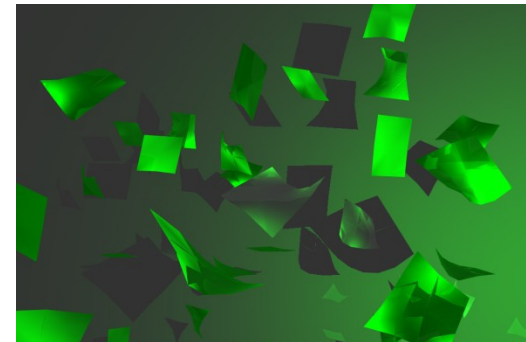
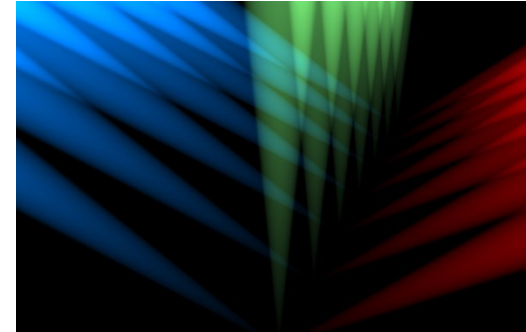
# INNOVATION: DOMINANT DESIGNS

- Creative synthesis of a new product innovation usually leads to creative destruction model (Schumpeter):
  - A monopoly (usually temporary)
  - High unit prices and profits
  - Sales of the product in a few market niches where it has greatest performance advantage over competing alternatives
  - Demand and production grow with more applications for product
  - New firms enter market with product variations
    - Example: automobile industry in 1910 (steam, electric, and internal combustion engines)
  - More firms, more experimentation, more failures
  - A few dominant firms, with dominant design, become static
  - New destructive technology from new, small firms starts process again



# INNOVATION: RECOGNIZING DOMINANT DESIGNS

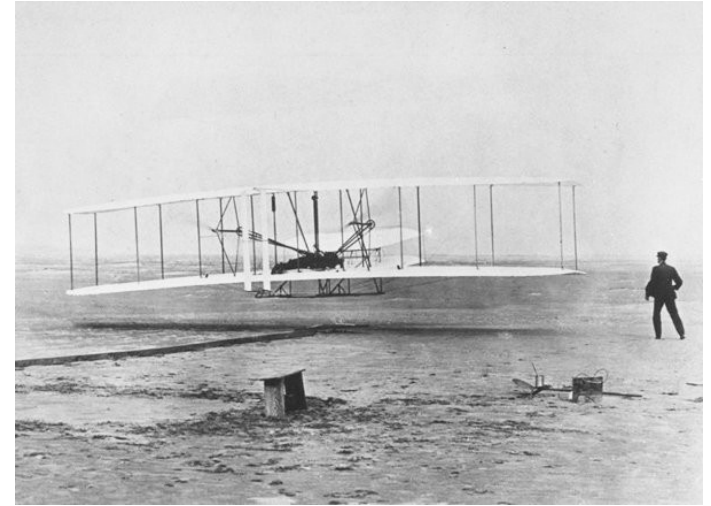
- Can dominant design be perceived (or predicted) when it first appears or only in retrospect?
- Three schools of thought:
  - (1) Dominant design is the result of chance events and cannot be predicted (but perhaps recognized)
  - (2) Inherent technology factors (and laws of nature) determine dominant design – it is deterministic and predictable
  - (3) Social & organizational factors determine dominant design – it can be predictable (usually with difficulty)
- Probably: combination of these three views
  - Usually dominant design cannot even be recognized except in hindsight (never mind predictable)
  - But look for design simplicity & technological elegance as indicator



# INNOVATION: COMPETING WITH DOMINANT DESIGNS

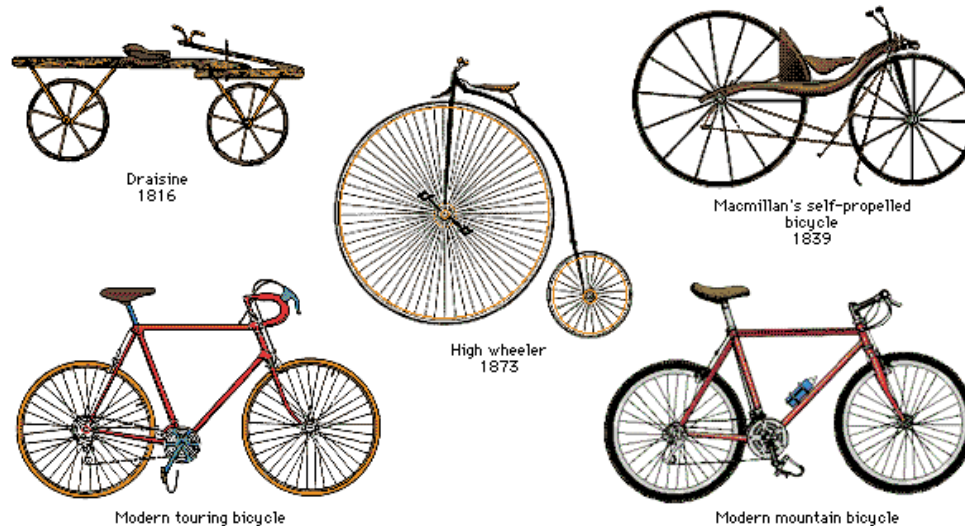
➤ Lesson for technology managers and business strategists is to understand constraints, already imposed by existing dominant design, on:

- **Systems**
- **User learning and habits**
- **Collateral assets**
- **Entry barriers**



# INNOVATION: DEVELOPMENT AND DIFFUSION

- Innovators (of disruptive technology) are often outsiders
- Social factors as important as technological factors (especially for consumer products)
  - Initial familiar appearance and operation to old technology, e.g., horseless carriages looked like horse-drawn carriages; first TVs looked like radios
- Established technology can ward off new entrants (for awhile) with defensive innovation – or legal challenges



# INNOVATION: ORGANIZATIONAL CHANGE

- An entrepreneurial organization formed organically around an innovation transforms into a large-scale producer of standard products
  - Informal management replaced by bureaucratic emphasis on goals, structure, and rules
  - Organization becomes hierarchical and rigid with formal tasks
  - Major innovations no longer encouraged – incremental improvements are preferred
  - Company loses its organic character
    - Shift from entrepreneurial skills to management skills



# INNOVATION: SUMMARY OF THE MODEL

## ➤ Product

- From high variety, to dominant design, to incremental innovation on standardized products

## ➤ Process

- Manufacturing progresses from reliance on skilled labor and general-purpose equipment to specialized equipment operated by low-skilled labor

## ➤ Organization

- From entrepreneurial organic firm to hierarchical mechanistic firm with defined tasks and procedures and few rewards for radical innovation

## ➤ Market

- From fragmented & unstable with diverse products and rapid feedback to commodity-like with largely undifferentiated products

## ➤ Competition

- From many small firms with unique products to an oligopoly of firms with similar products



# INNOVATION: NON-ASSEMBLED PRODUCTS

- Non-assembled products (components of assembled products, e.g., glass, steel, paint, chemicals, fibers, etc.)



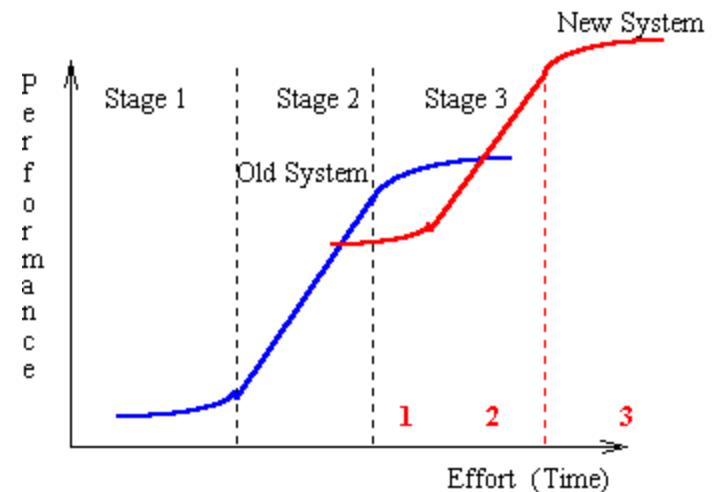
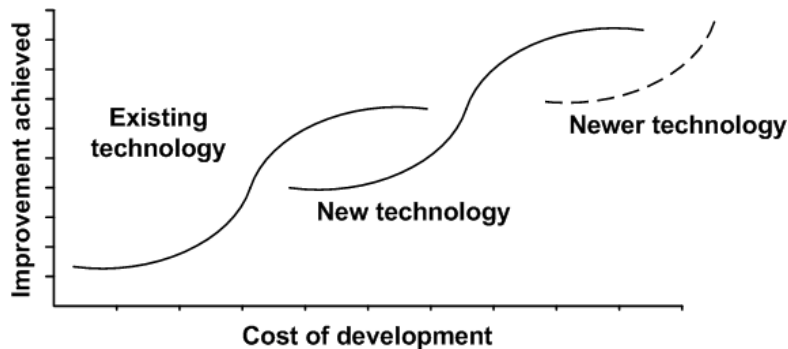
# INNOVATION: NON-ASSEMBLED PRODUCTS

## Comparison of *Transitional Phase* for Assembled and Non-Assembled Products

CHARACTERISTIC/PRODUCT	ASSEMBLED	NON-ASSEMBLED
<b>INNOVATION</b>	Emphasis on incremental product improvement & product variation	Emphasis on process changes required by rising demand
<b>SOURCE OF INNOVATION</b>	Users; manufacturers	Manufacturers; equipment makers
<b>PRODUCTS</b>	Many features unique to individual producers	Increasingly undifferentiated
<b>PRODUCTION PROCESSES</b>	Some sub-processes automated	Becoming more: rigid, continuous, capital intensive
<b>EQUIPMENT</b>	Special-purpose equipment being introduced	Special-purpose
<b>PLANT</b>	General-purpose with specialized sections	Single-purpose, but small
<b>COST OF PROCESS CHANGE</b>	Moderate	High
<b>COMPETITORS</b>	Many, but declining in numbers after emergence of dominant design	Many, but declining in numbers after emergence of enabling process
<b>VULNERABILITIES OF INDUSTRY LEADERS</b>	To both improved products & more efficient producers of current products	To more efficient & higher quality producers

# INNOVATION: ESTABLISHED VS. INVADING PRODUCTS

- **The Technology S-Curve depicts the ongoing replacement of established products with new (invading in the market) products**
  - Sometimes the established product delays replacement with a burst of improvement in Stage 3
  - Established product continues to sell because often users reluctant to adopt new technology (especially if effectiveness, efficiency, reliability unproven)



# INNOVATION: CORPORATE RENEWAL

- **Continuous renewal of established products**
  - **Incremental improvement with equal emphasis on product and process design**
  - **Performance, reliability, cost**
- **Properly defining core competencies**
  - **Old vs. new; broad vs. narrow**
- **Product mortality**
  - **Slow vs. quick end**
  - **Radical innovation to extend product life**



# INNOVATION: CORPORATE RENEWAL

- **Radical innovation difficult in established firms**
  - **Conservative management**
  - **Expensive, difficult to justify**
- **Piecemeal approaches fail**
  - **Portfolio approach: ranking prospects as a function of predicted returns**
    - Typically leads to grab bag minor product or process improvements
  - **Mergers & acquisitions (for innovation)**
    - Often unsatisfactory – assets are brains of entrepreneurs who quickly leave (cultural clash and new company too stifling)
  - **Alliances**
    - Can be successful if cultural differences accommodated
    - **Larger company:** technical, manufacturing, financial, and marketing ability
    - **Smaller company:** entrepreneurial, creative, innovative ability



# INNOVATION: CORPORATE RENEWAL

- Established companies need a focused, systems approach to innovation
- Organize separate divisions & alliances
  - Dedicated to radical, disruptive (transformational) technology
  - Focused on and bridging technological and product discontinuities
  - Rejuvenate mature company and products
  - Caution: inventive genius does not guarantee innovative success (e.g., Xerox PARC)

