

Cybernetics

Malcolm Ballantine

23 February 2023

Halesworth

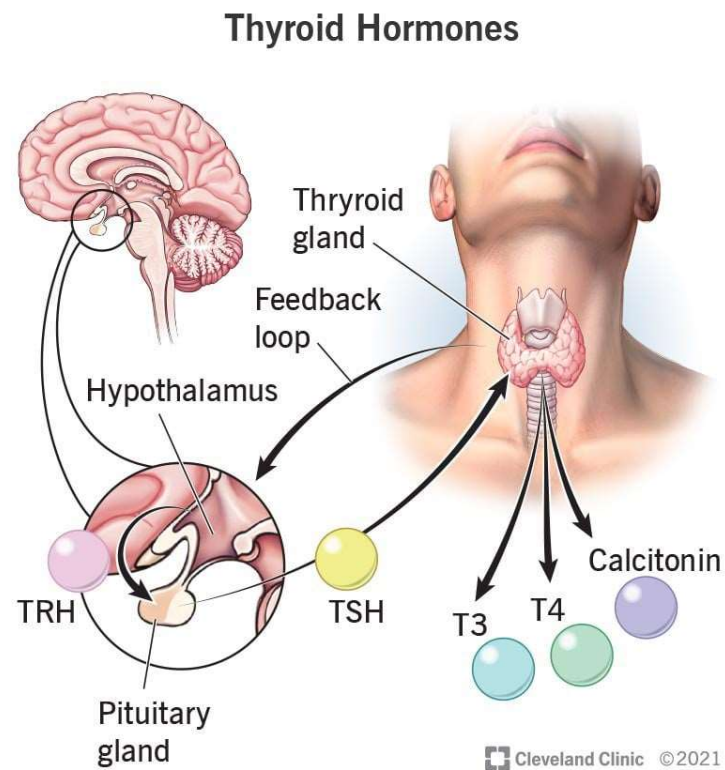
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Cybernetics

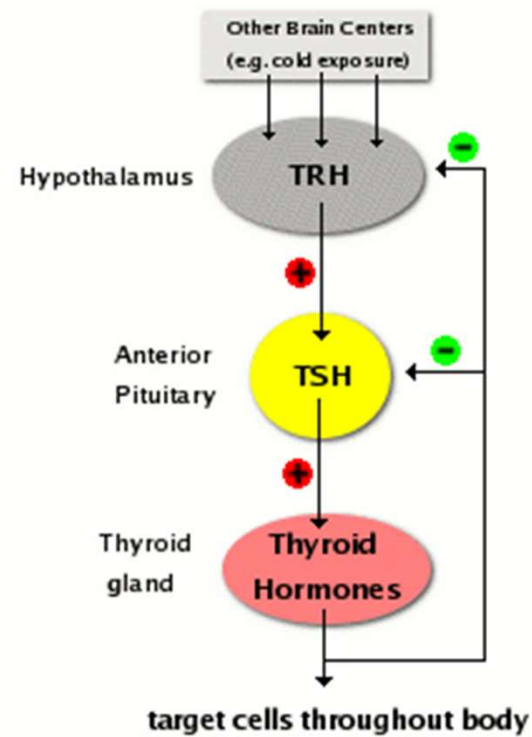
- 'Control and Communication in the Animal and the Machine'

Norbert Wiener

Regulation of the Thyroid Gland



Regulation of the Thyroid Gland

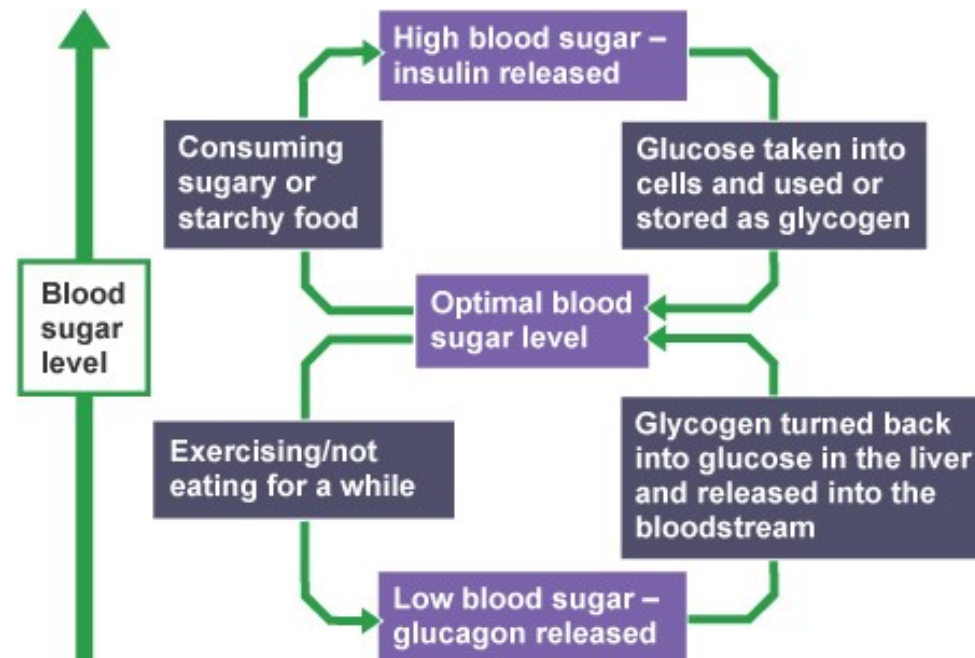


Colorado State University

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Another Example – Glucose Regulation

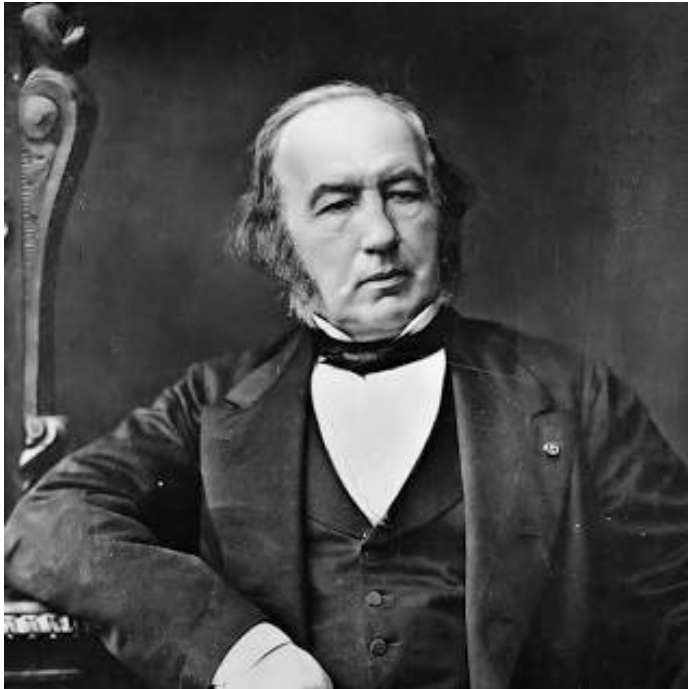


BBC

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Claude Bernard (1813–1878)



**'La fixité du milieu
intérieur est la
condition de la vie
libre.'**

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Walter B Cannon (1871–1945)



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'Homeostasis does not occur by chance, but is the result of organized self-government'.

'The Wisdom of the Body' (1932)

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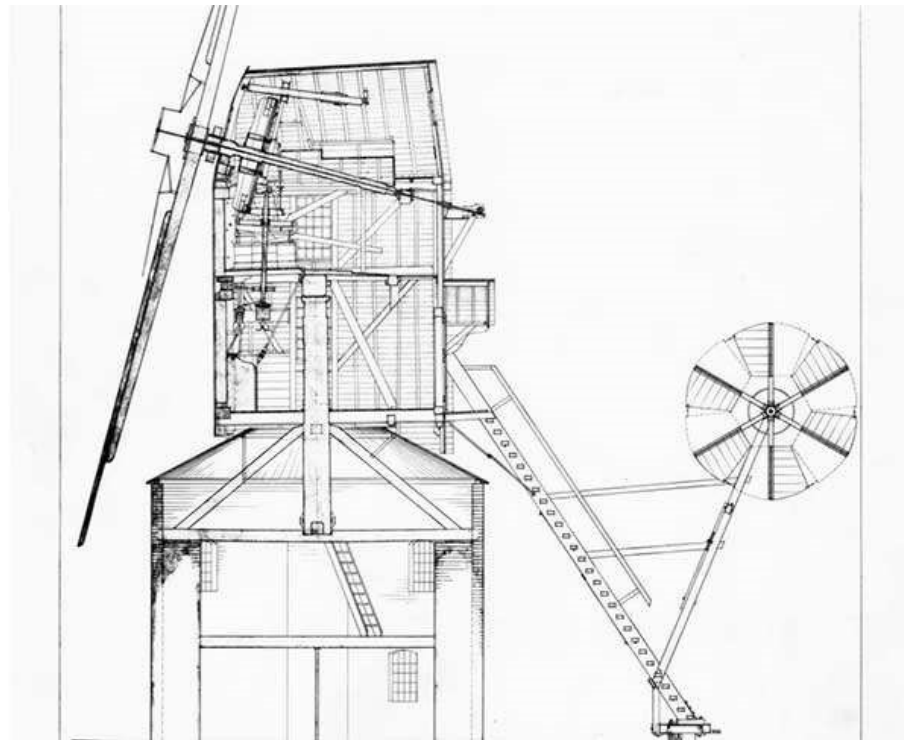
Saxtead Post Mill



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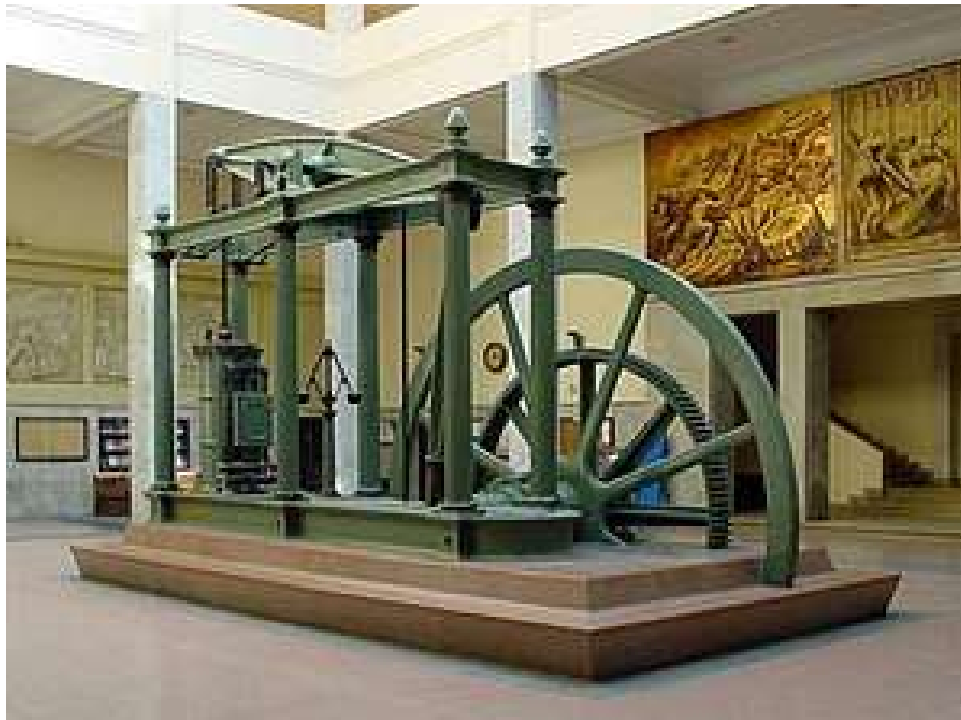
Saxtead Post Mill



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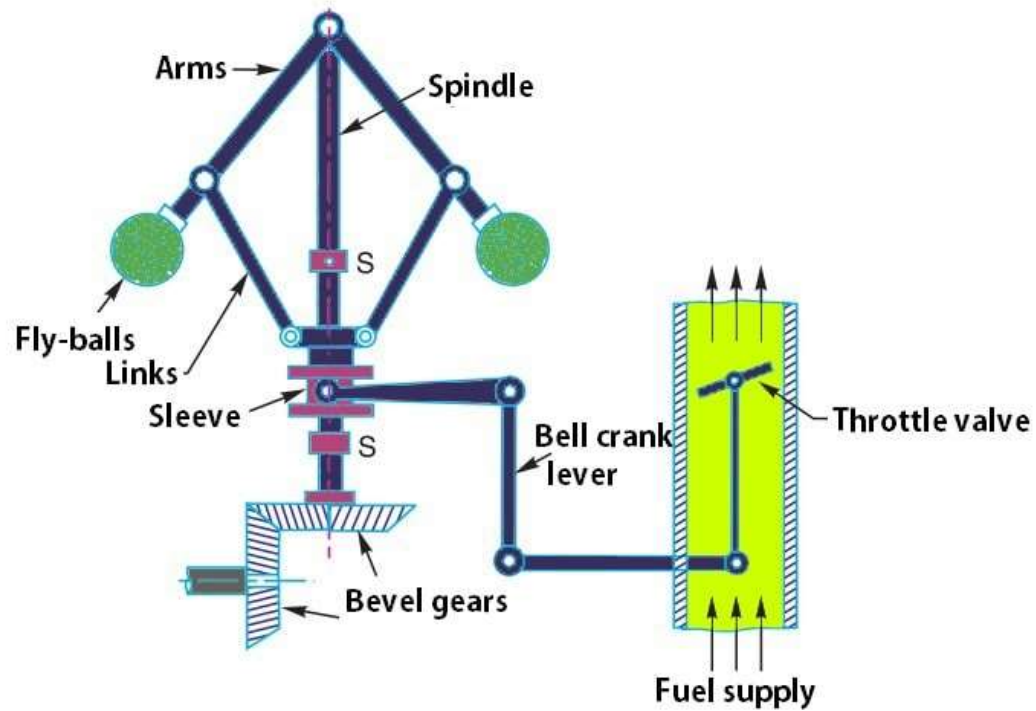
Watt Steam Engine



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Watt Governor

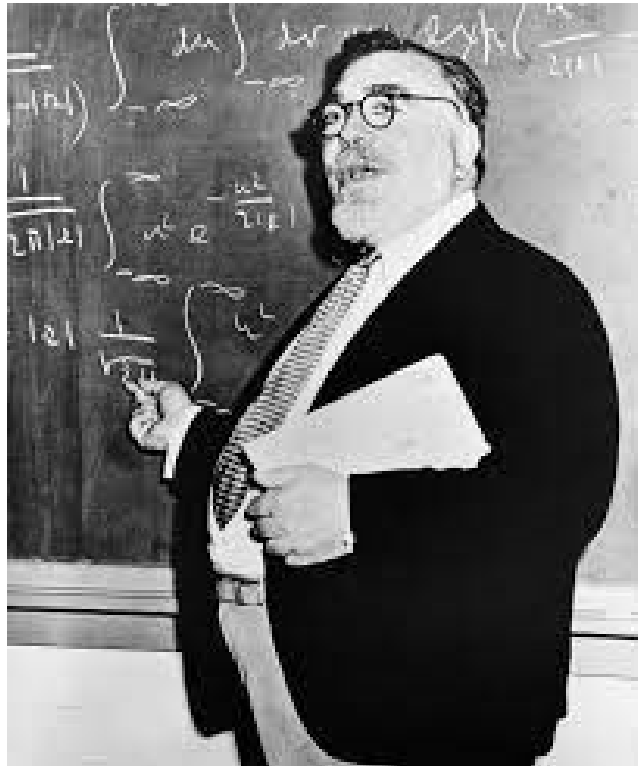


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Norbert Wiener



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Norbert Weiner (1894–1964)

- Graduated from High School at age 11
- BA in Mathematics at age 14
- Started Zoology degree at Harvard
- Transferred to Cornell to study Philosophy and graduated at age 17
- Returned to Harvard and completed PhD in Mathematics at age 19
- Postdoctoral studies at Cambridge with Bertrand Russell

Cybernetics

κυβερνητικής

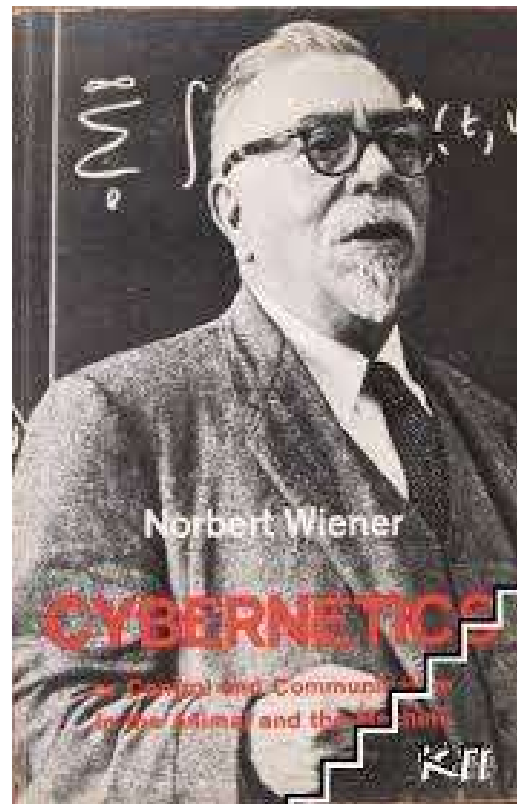
kubernētikēs

(Helmsman)

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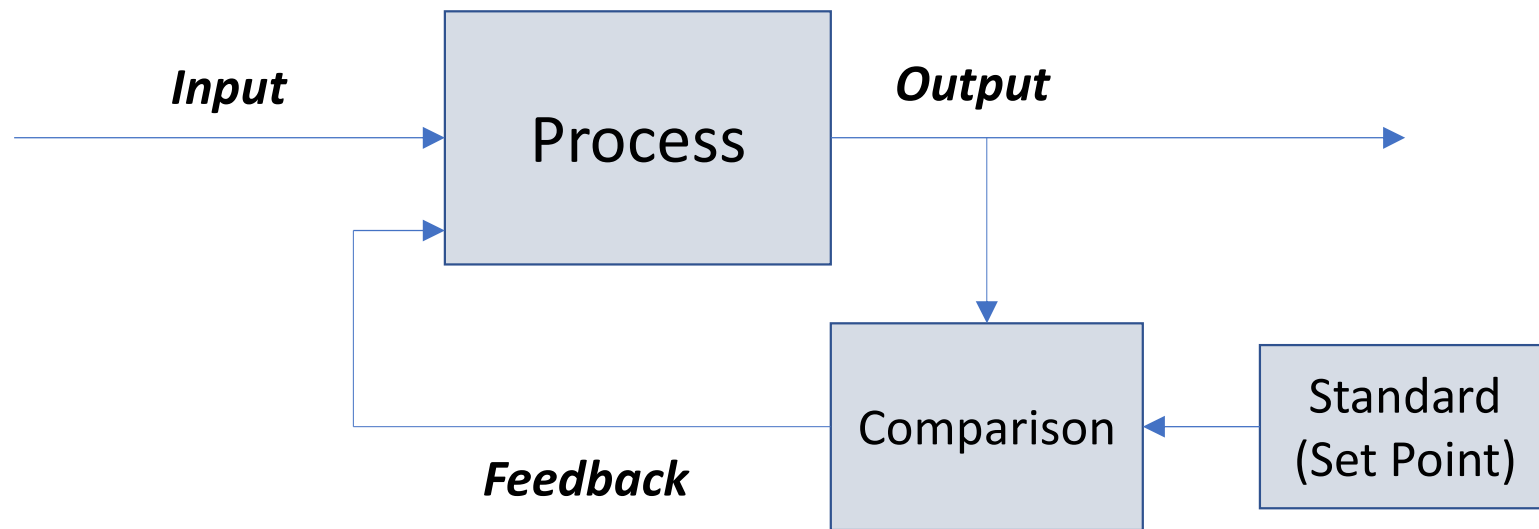
Cybernetics (1948)



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Feedback Control



Feedback

- Negative – Reduces deviation from desired value (stabilising)
- Positive – Increases deviation from desired value (destabilising)

Feedback (a more complicated view)

But still fairly simple...

- The explanation assumes that feedback is instantaneous
- There will probably be delays
- Input delays – ie delays in changes registering in the system
- Output delays – ie delays in outputs taking effect

Feedback Errors

In the worst case, because of delays:

- The system will increase the output when it is already increasing (or decrease it when it is already decreasing)
- What is intended as negative feedback is unintentionally positive

More likely:

- The output will oscillate around the intended state
- This was known to 19th Century engineers as 'Hunting'

A Complex Example – Steering a Ship

- To change course on a boat or ship, a complex series of actions must be followed – this is always true but the complexity is most easily seen in a large vessel
- To change course by, say 5° to starboard, the wheel must first be turned in the starboard direction
- It must then be turned in the port direction (or the vessel will continue to turn to starboard)
- A complex set of actions then follows to stabilize the new course – mathematical analysis reveals the complexity

A Physiological Example – Ataxia

- Usually caused by damage to the cerebellum
- Results in:
 - poor co-ordination
 - Walking unsteadily
 - Poor balance
 - Difficulty with fine motor tasks
 - Swallowing
- Weiner argued that these effects were due to faulty feedback within the nervous system

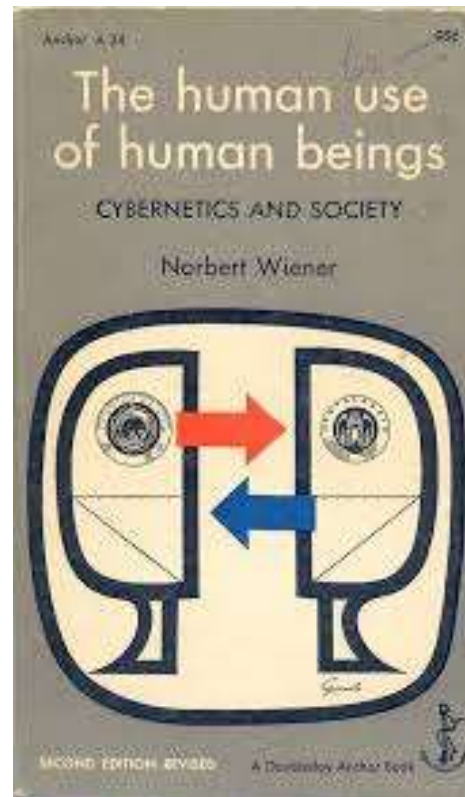
Weiner's Approach...

- Was to present a comprehensive mathematical analysis...
- ...which forms the basis of modern Control Engineering
- Weiner also re-conceptualised feedback control as the means by which entropy could be reduced without contravening the Second Law of Thermodynamics
(which states that entropy must always increase
–to put it another way: Chaos is more likely than Order)

Re-defining the field...

- *How organization increases in some parts of the Universe, against the odds, is the study of Cybernetics*

The Human Use of Human Beings



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The Human Use of Human Beings

- In *The Human Use of Human Beings*, Weiner extended his ideas to include application to the human and social sciences
- In his view, automation would become possible
- He supported the use of automation to reduce the drudgery and monotony of low productivity jobs
- He believed that it should be used to enhance human effort, not replace it, in a collaborative relationship between people and machines

Norbert Wiener influenced...

• John von Neumann	<i>Computer Scientist</i>
• Gregory Bateson	<i>Anthropologist</i>
• Margaret Mead	<i>Cultural Anthropologist</i>
• W Grey Walter	<i>Neurophysiologist</i>
• Talcott Parsons	<i>Sociologist</i>
• J C R Licklider	<i>Psychologist/Computer Scientist</i>
• Daniel Katz & Robert Kahn	<i>Organizational Psychologists</i>