

Dismounting the Tiger of Perpetual Growth

Lessons from nature on how to produce a robust, sustainable global society

(Abstract and Introduction for a talk given at MIT and the University of Maryland in November 2005)

By Edwin Lee

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Abstract

Modern civilization requires perpetual growth to produce full employment and to avoid economic collapse. This is not merely a convenient article of faith for politicians and neoclassic economists; it is a dangerous and unsustainable system artifact which makes serious efforts at energy conservation, conservation of natural resources, or limits to population growth politically untenable. This book describes the system elements which produce the artifact and proposes design modifications which would eliminate it.

Introduction

As described by Herman Daly and Joshua Farley in their book "*Ecological Economics*:" the economic system is a subsystem of nature and utterly depends on natural capital for resources and energy.[1] For the last 300 years, the economic system of Western Civilization has also had to grow continually in order to provide full employment. Two consequences of this have been a population explosion and an ever increasing draw down of natural capital. Since Earth is a closed system with respect to matter, natural capital is limited. Therefore, growth in demand and consumption must end; either through human design or natural disasters.

However, the existing economic system is so structured that it triggers mass unemployment when demand merely levels off; which makes it political suicide to suggest growth limiting solutions to resource and ecological problems. In fact, during the last six years the US has postponed a serious recession through short term policies that increased consumer spending. These policies included low interest rates, massive increases in credit card debt and home loans, tax cuts, huge Federal deficits, and public and private borrowing of over \$3.2 trillion dollars from other nations; more than \$11,000 per citizen!

All systems are compromises, results of tradeoffs between desirable and undesirable features. One universal tradeoff is between efficiency and life expectancy (or sustainability). The more efficient any system is the more fragile, less sustainable, it is. I suggest that this is a universal design principle

which we need to understand. The growth and globalization of our economic system is currently driven solely by "increasing efficiency" as measured by Generally Accepted Accounting Principles. This measuring system does not measure or evaluate robustness or sustainability; therefore its apostles have no sense of the tradeoffs being made in the blind march to ever greater efficiencies. Should we ever achieve a unified global economy, its life expectancy would be at most a few years, probably followed by an enduring global Depression.

I will describe the architectural features of the modern economic system that make perpetual growth a prerequisite to full employment. Two principal features are: it is single ended rather than differential and it is a living system rather than an inanimate one. However, there are practical changes to this architecture which would make it differential and thus sustain reasonably full employment whether demand increases, decreases or remains stable. These changes include: relentless recycling, de-globalization, well regulated economic and political borders, term-limits, and a cultural embrace of random economic and political failures. It is as counter-productive to prevent all economic or political failures as it is to prevent all forest fires, avalanches or hurricanes.[2]

Economic and political systems depend on natural systems in two equally important ways: 1) through physical constructs of matter and energy as *Ecological Economics* proposes, and 2) through mental constructs in human brains, as explained in this talk. Both sets of constructs are real. Human beliefs and expectations power the economic system; not money. They require matter and energy to create and to maintain and even greater energy to alter.

The human brain is a biological system with its own set of design tradeoffs. Its characteristics have evolved to improve the human species' survivability in natural ecosystems; they have not evolved to effectively process non-immediate issues in a complex society. Each brain develops synaptic patterns which operate through neural

pathways to encode and store myths: massively redundant, crude representations of reality. These myths include beliefs, habits, memories and expectations. Varying subsets of myths motivate a person's economic decisions and actions.

However, each human brain operates in a state of constant, overwhelming overload, as it integrates new sensory inputs with previously encoded myths. To operate at all, it must relentlessly triage new inputs in a way that enables it to deal quickly with immediate threats and opportunities. This biologically based triaging process couples with personal and cultural myths to severely restrict the information we become conscious of and respond to. We'll discuss the last five steps of triaging (denial, anger and blame, bargaining, depression and acceptance) and demonstrate how they interfere with recognizing non-immediate challenges and initiating pro-active rational behavior.[3] We'll also address how to work through these steps to produce cultural changes that support sustainable economies.

The proposed design changes to the physical economic system and to modern economic beliefs are merely applications of the design principles of nature; natural systems have sustained life on Earth for nearly 4 billion years while producing the surplus of natural capital that we are squandering. We would do well not merely to respect what nature gives us, including the brains we use to think with, but to respect and adapt the engineering principles that produced life's abundance, diversity and sustainability in a closed system. In my opinion as an engineer: nature's engineering principles are frequently more intelligent than our own. A little humility might help us out of the systems' mess we've gotten ourselves into. _____

A slide presentation of this talk and a pdf file containing the handouts are available at:

www.elew.com

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References and Suggested Readings

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Dismounting the Tiger of Perpetual Growth



Design lessons from nature on producing a sustainable society
by Ed Lee

Abstract

- Modern economies require perpetual growth to produce full employment and to avoid collapse.
- This is not merely a convenient article of faith for politicians and neoclassic economists; it is a dangerous and unsustainable system artifact that undermines serious efforts at conservation of energy and natural resources, or at a sustainable human population
- This talk describes factors which produce this artifact and design modifications which would eliminate it.

Outline

- Riding a tiger
- Conceptual tools
- Living systems
- Modern economic systems
- Role of human brains
- The dismounting process

Riding a tiger

- Not for the faint of heart
 - We live in "interesting times"
- Global challenge
- US challenge
- Economic challenge

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Global challenge

- Global growth is strip mining the biosphere
 - Rapidly depleting fossil fuels, fossil water
 - Mixing ecosystems: flora, fauna, microbes
 - Depleting and polluting oceans
 - Global warming
- 6.5 billion people: probably twice biosphere's carrying capacity for current standards of living and science
 - Population continues to increase
 - Carrying capacity continues to decrease

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US challenge

- US growth involves massive current account deficits
 - Borrowed ~\$700 billion in last 12 months, over \$2,300 per capita (~ 50% funding Federal deficit)
 - Borrowed \$3.2 trillion (\$11,000 per capita) in last 6 years
- Economic strains
 - Personal savings rate less than 1% of personal income in 2004 (down from >8.5% 1948-1985), negative in 2005
 - Public and private debts are increased to keep consumers buying and to avoid recession
 - US fiscal policies digging deep holes in the future
 - Medicare, Social Security, Debt financing, Tax policies

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The economic challenge

- Our global economic system requires perpetual growth in demand from
 - Increasing standards of living
 - Population growth
- Perpetual growth has already produced
 - Physical constructs that deplete natural capital at an alarming rate
 - Mental constructs that
 - Include ever more unsustainable expectations
 - Have depleted the average level of human happiness

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Questions we'll address

- Things can't be this bad
 - Why do we "feel" like things are going fairly well?
 - Why aren't economists and politicians addressing the issues?
 - Why would other countries lend us money if we can't repay it?
- What can be done about it?
 - How do we avoid disaster?
 - What would be a successful outcome?
 - How do we get started?
 - Is success certain?

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Conceptual tools

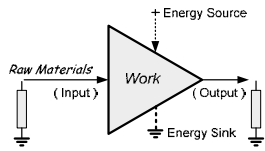
- Some fundamentals of Systems and system tradeoffs
- A comparative overview of designs
 - Living systems
 - Systems of modern civilization

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A system does work



- Transposes a relatively unorganized input to a more organized output as defined by some pattern and/or by the structure of the system itself
- May include "sub-systems"
- **Always** a subsystem in some larger context

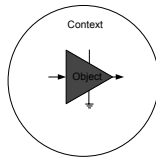
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A system is an object in a context

- Well regulated borders
 - Multi-dimensional including space and time
 - Selectively couple and decouple a system and its context
- Limits and tradeoffs
 - Boundaries, resources, energy



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Systems and Energy Sources

	Nature	Civilization
Systems	Mitochondria Cells Plants Mammals Immune Systems Human Brains Ecosystems Biosphere	Motors Amplifiers Cars and Trucks Refrigerator Home Heating Businesses Transportation Economies
Energy Sources	Solar ATP	Fossil fuels Electricity Batteries

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A basic difference

- Inanimate system
 - Work produces something other than itself
 - Work function can be turned on and off
- Living system
 - The work produces and sustains populations of the living system itself
 - Work functions cannot be turned off without depleting populations of the system
 - Use it or lose it

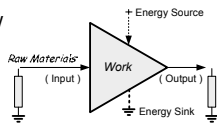
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Designs are always trade-offs

- Gain: How much
- Stability: How steady, how certain
- Bandwidth: How fast
- Dynamic Range: extremes of operation
- Offset: Averages required to function properly
- Adaptability: Changes of context it can work with
- Life expectancy: how long it should work properly



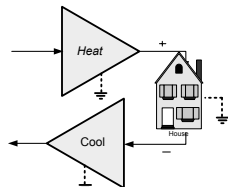
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Single Ended and Differential Systems

- Furnace alone
 - Single ended
 - Only works properly above outside temperature
- AC alone
 - Single ended
 - Only works properly below outside temperature
- AC + Furnace
 - Differential
 - Works properly above, below and at outside temperature

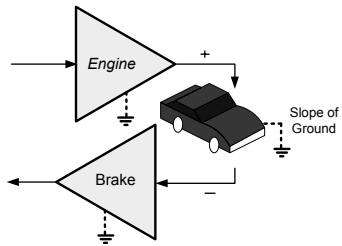


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Differential controls for Cars



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Tradeoffs: differential vs single-ended

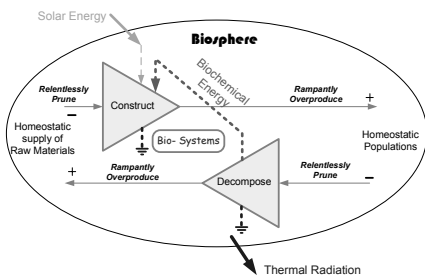
- **Differential Systems**
 - Vastly wider dynamic range
 - No offset
 - Much faster responses
 - Less noise sensitive
 - Orders of magnitude more adaptable
- **However Differential Systems**
 - At least twice as complex
 - May use more energy

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Living Systems are differential

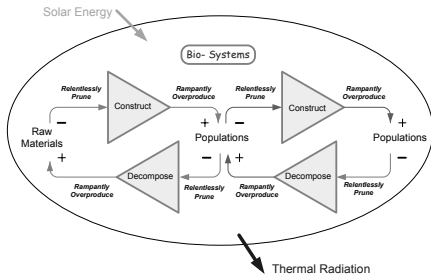


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Multiple pathways of living subsystems



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Sustainable living systems

- Populations/ Systems are
 - Rampantly overproduced, relentlessly pruned
 - Robust during population growth, stasis or shrinkage
- Collectively recycle everything
- Are overwhelmingly decentralized and local
 - Well regulated borders
 - Term limits for individuals

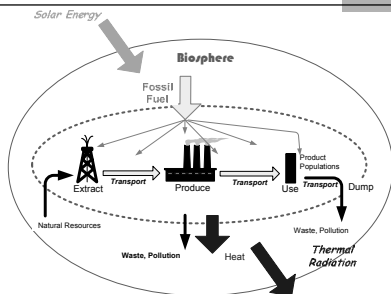
Mitochondria
Cells
Plants
Mammals
Immune Systems
Human Brains

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Economic system's material flow

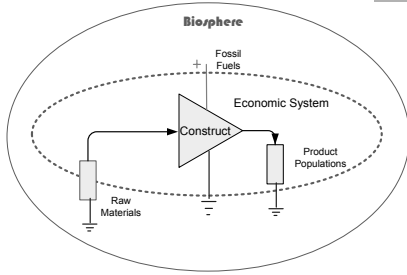


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Modern economies: single ended systems



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Compare Designs

- Systems of Nature
- Modern Economic System

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Objectives

Nature	Civilization
Facilitate a robust, adaptable, globally sustainable living community: life itself	Produce a politically stable, globally integrated society that is molded by economic efficiency as measured by Generally Accepted Accounting Principles ¹ (level playing field?)

¹Put all your eggs in one basket: that's the most efficient way to carry eggs

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Design Principles

Nature	Civilization
Overproduce and relentlessly prune	Build and maintain
Recycle everything: locally and often	Use, transport far away and dump
Establish well regulated borders	Eliminate economic borders and barriers (globalize),
Establish term limits	Control and own as long as possible

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Construction Policies

Nature	Civilization
Massively redundant weak connections (Velcro and post it glue)... reversible	Rivets and welds ... Irreversible
Massively redundant differing pathways and response times	Just in time, the fastest most efficient path
Limited palette of recyclable raw materials used everywhere	Unlimited palettes of materials: anything that works once
Sustainable stability through diversity and adaptability	Temporary stability through control and scale

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Strategies

Nature	Civilization
Decouple, decentralize and diversify Promote local control	Integrate (globalize), centralize and standardize Promote absentee ownership
Equally favor all strategies from symbiosis and to relentless competition	Promote co-operation but eliminate competition and adversity
Pay as you go, produce surpluses to save for the future	Borrow from the future, consume nature's accumulated surpluses

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Comparative Energy Policies

Nature	Civilization
Use solar energy, produce reservoirs of biochemical energy and oxygen	Consume nature's limited reserves of fossil fuels
Recover and use construction energy through decomposition	Consume energy in transportation Squander recoverable energy
Use living systems and their waste to loosely regulate global climate	Heedlessly pollute the atmosphere

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First Principle

Nature	Civilization
Embrace Uncertainty in processes and outcomes <i>(Employ the 2nd Law of Thermodynamics)</i>	Eliminate Uncertainty in processes, outcomes and human expectations <i>(Try to Ignore the 2nd Law of Thermodynamics)</i>

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A Curious Thought

- There is a raging debate over blind evolution versus intelligent design in Nature
- Perhaps we might better ask:
Is there any evidence for intelligent design in our modern Economic System?

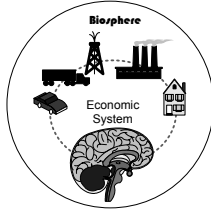
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The economic system

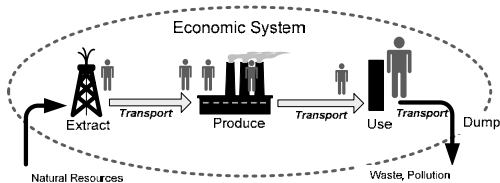
- Is a subsystem of the biosphere
- Interacts with natural systems in **two** critical ways; through
 - *Physical constructs of matter and energy*
 - *Mental constructs of beliefs, skills and expectations*



Two roots of modern economic systems

- Engine: powers physical constructs
 - Invented in Britain to pump water out of coal mines in the 18th century
 - Evolved to power transport and construction (production)
 - Replaces or amplifies human and animal labor
 - Subject to 2nd law of thermodynamics
- Double-entry bookkeeping: shapes mental constructs
 - Invented in Italy for shop keepers in the 14th century
 - Evolved to GAAP
 - Establishes commonly held beliefs and expectations about wealth and liquidity
 - Decouples finances from the 2nd law of thermodynamics and from nature (fiscal perpetual motion and more!)

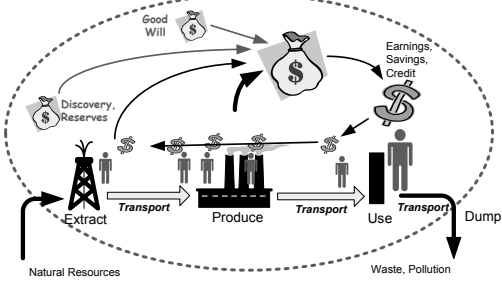
People make it a living system



Each operation in the materials' pathway is a living sub-system of "people, methods and materials"

Therefore: one purpose of each operation is its own health

Wealth and liquidity beliefs energize people's actions



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Wealth and liquidity beliefs

- Are arbitrarily inflatable
 - Good will
 - Discovery (Reserves)
 - Forgery
 - Credit
 - Broke in 1950 when you ran out of cash
 - Not broke today until you max out the credit cards and home loans
- Violate the 2nd law of thermodynamics

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The financial system is

- Entirely faith based
 - Commonly held beliefs are all that make it work
 - Supported by rituals
 - Money from the ATM
 - Payment rituals at work and shopping
- Economists are theologians
 - Globalization supporters are conceptual Catholics
 - Ecological Economists are Protestants
- We need an economic Reformation

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The physical growth dilemma

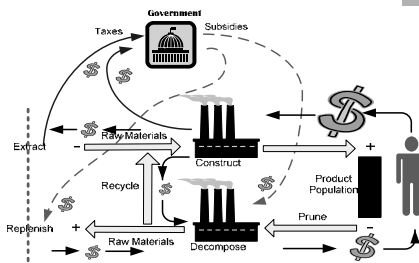
- Once the growth phase ends for a product population then:
Production rate = trash rate
- As time passes, efficiency improvements mean that employment per unit of production drops
- Therefore
 - As a market saturates there is a sharp loss of employment
 - As time passes there is a further loss of employment
- Growth is the “offset” needed to keep this single-ended, living system, healthy

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Solution: Establish relentless recycling



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Relentless recycling

- Deconstruction system pays significant repurchase price
 - Target > 10% of original purchase price
 - May vary to adjust flow rate out of population
 - % would increase as recyclable content increases
- Purchase price increased by taxes
- Repurchase price increased by subsidies

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Energize with taxation and subsidies

- Tax product
 - Materials not yet recyclable
 - Cost to recycle
- Tax extraction
 - Cost to recycle
 - Known reserves to depletion
 - Cost to restore local area
- Subsidize
 - Deconstruction
 - Restoration of depleted region

Product examples

*Vehicles
Electronics
Appliances
Furniture
Homes
Factories
Food*

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Impacts of relentless recycling

- Initially
 - Increases employment per unit of product population
 - Reduces rate of consumption
 - Lowers average standard of living as currently perceived
- Sustains employment with level or decreasing populations (keeps living system alive)
 - Workers can shift from production to decomposition
- Responds more quickly to disasters
- Materials recycled indefinitely
 - Reduces pollution
 - Prevents eventual loss of jobs from depletion of raw materials
- Increases rate of product population turnover
 - Improvements adopted faster

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The role of human brains

- The financial aspects of the economic system are entirely matters of beliefs and expectations
- Beliefs and expectations must change to
 - Enable and sustain any physical modifications
- What will it take to modify GAAP beliefs?
 - They are complex structures, interconnected with other beliefs and with the beliefs of others

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Human Brain is physical

- Evolved biological construct
 - ~ 100 billion neurons (10^{11})
 - > 100 trillion synapses (10^{14})
- Memory, beliefs, skills stored as
 - Massively redundant, populations of synapses interconnected by redundant paths and loops
- Runs on ~20 watts (20 joules/second)
 - 20% of body's total energy budget
 - Powered by $> 3 \times 10^{20}$ molecules of recycling ATP
 - Dim bulb

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Beliefs, expectations, skills

- Takes "work" to physically construct them in a brain
- Are adaptable, based largely on experiences, relationships and contexts
 - Contexts and relationships filter (look around demo)
 - Recent experiences have more impact than old
 - Repetition adds strength
- Qualia (conscious perception of lights, sounds, words, faces, emotions, etc.) generally depend on which path related signals come through
 - Rational thought is one of hundreds of "weak" qualia
- Brain constructs personal reality in pre-frontal lobe from massively redundant flow of selected "qualia"

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Your Brain Adapts To Read This

- I cdnuolt blveiee taht I cluod aulacilty uesdnatnrd waht I was rdanieg.
The phaonmneal pweor of the hmuan mnid. Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mtttaer in waht oredr the ltteers in a wrod are, the olny iprmoatnt tihng is taht the frist and lsat ltteer be in the rghit pclae. The rset can be a taotl mses and you can siltl raed it wouthit a porbelm. Tihis is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

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Brain's constructs

- Similar to systems of "people, methods and materials" in large cities, large companies and the Federal Government
- Conscious mind is equivalent to Mayor, CEO, or President of the United States
 - Loosely connected to reality through organizational constructs
- At least twice as difficult to change an existing construct as to develop a new one

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Brain evolved to triage and react

- There is a continual, overwhelming flood of sensory data and memories
 - Like a hospital that can handle 10 patients/day but has 10,000 /day arrive at the door
- Evolved to best identify and react quickly to threats and opportunities that impact immediate survival
- Not evolved to pro-act about non-immediate, complex issues

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Medical triaging

- Rapidly filters out patients that
 - Don't need attention
 - Can wait
 - Others can handle
 - Are too far gone to help
- Accepts kinds and number of patients that
 - Can be helped with available resources

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The last five steps of brain's triaging¹

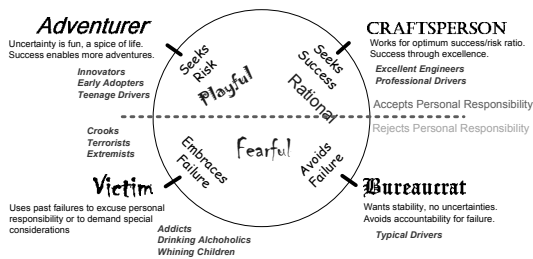
- Denial
 - no change necessary
- Anger and Blame
 - they have to change
- Bargaining
 - simple change that leaves old belief structure in tact
- Depression
 - Phase 1: Letting go of old
 - Phase 2: Embracing new
- Acceptance
 - Facing new reality and making best of it one day at a time

¹ From *Death and Dying* by Elisabeth Kubler-Ross, M.D.

Brain also triages through

- Beliefs, expectations
- Context
 - Environment
 - Attention
- Attitudes

Decision Making Attitudes



Decision making systems

- Young, small, innovative systems
 - Led by Adventurers, supported by craftspeople
 - Relatively few Bureaucrats
 - Strategy: Take risks; adapt to market, suppliers, and competitors
- Old, large, successful systems
 - Led by Bureaucrats and cautious Craftspeople
 - Bureaucrats dominate management and working levels
 - Strategy: Avoid risks, regurgitate and protect past success; condition market, suppliers and competitors

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Failure is necessary: past success produces unsustainable expectations

- Past experiences
 - Most recent past has greatest weight
 - Repeated experiences reinforce
- Beliefs of others
 - Family, work, social, religion, nation, culture
- Education
- Stresses build when expectations exceed capacity of physical systems to deliver
- Economic and Social failures reset unsustainable expectations and habits

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The “greatest generation”

- Reached adulthood during a Depression and WWII
- Everyone sacrificed and saved as a result
- Built an economy that didn't require their progeny to sacrifice or save
- The savers began dying off in the 1980's
 - Two generations of borrowers
 - Immediate gratification, flood of credit
 - Government and business guarantees, and credit replace personal savings

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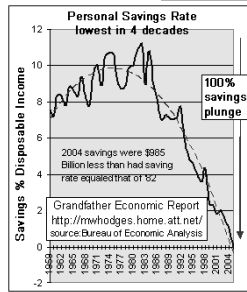
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Personal savings rate 1950-2005

Had we saved in 2005 at 1986 levels we would have saved over \$800 billion, enough to eliminate the current account deficit!

In 2005 the personal savings rate is negative!



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Other countries lend more to us because

- They believe(d) that we have a robust, diverse economy
- Of the first principle in borrowing:
 - If you owe the bank a million \$; **You're** in trouble
 - If you owe the bank over 4 trillion \$: the **Bank's** in trouble
- We're in a co-dependent economic relationship
 - We (borrowers) are the addicts
 - The savers are the pushers

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Dismounting the tiger

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A picture of success

- A family of economies and political systems that will (as a whole)
 - Replenish natural capital
 - Increase the average level of human happiness
 - Successfully adapt to random changes in nature

From nature's design principles

- Relentlessly decompose and recycle
- Minimize non-local transportation
- Fiercely regulate borders and term limits
 - de-Globalize
- Small groups adapt faster than large groups
- Consciously support massively redundant processes and outcomes
- Live with local uncertainties

Personal dismount algorithm

- Study the basics
- Develop an exciting vision of personal success within probable social contexts
 - Chose realistic trade-offs rather than seek an "ideal"
- Develop a marketing plan
- Implement, adapt and recycle

Helpful basics

- Biological systems
 - Microbiology
 - Immune systems
 - Eco-systems
- Human brains
 - Biological tool to construct and deconstruct beliefs
 - Anticipate and appreciate reactions of others
 - Extract design ideas for natural engineering

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Develop pictures of personal success

- Decide which issues you most want to address
 - *"Better to light a candle than to curse darkness"*
- Evaluate personal, family, herd commitments
- Support locally sustainable, living solutions

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Develop a marketing plan

- Associate with those who share objectives
 - Support groups, networking, examples of success
- Market locally
 - To adventurers: sell challenge, develop examples of success
 - To craftspeople: sell features; productize success
 - To Bureaucrats: use repeated successes to sell benefits
- Go regional and national

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Public Policy

- Well regulated political and economic borders
 - Global trade <10% of GDP
- “Pay as you go” National Economy
 - Range of annual budget imbalances tied to automatic tax increases/decreases for later years
 - No defined benefit programs: only defined cost ones

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Public Policy changes

- Diversify taxes
 - Reduce % on net incomes
 - Steep taxes on un-recyclable goods
 - Tax un-recyclable (transportation) energy
 - Tax “absentee” ownership of land and corporations
- Massive startup incentives to relentless recyclers

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Public Policy

- Keynes “trade balance” regulators
- Pay as you go businesses
 - Replace guaranteed benefit plans with pay as you go ones
- Address inequities indirectly through scale caps and economic localization
- Accept periodic recessions as necessary to reset collective expectations
 - Decoupling of systems keeps them all from going at once

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Other possibilities

- Term limits on
 - Ownership of private property
 - Leadership of all public corporations with over 500 employees
- Incentive compensations appropriate to position
 - For top executives: performance of organization, as compared to competitors, in decade after they leave

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When all is said and done

- There are no silver bullets
- There are no guarantees of success
 - We can only influence personal and social probabilities
- The future will not be boring for our progeny
 - They too will have to adapt
 - They will be necessary to themselves
- They probably will live in "interesting times"

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Information

- A PowerPoint file of this presentation is available at: www.ew.com

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