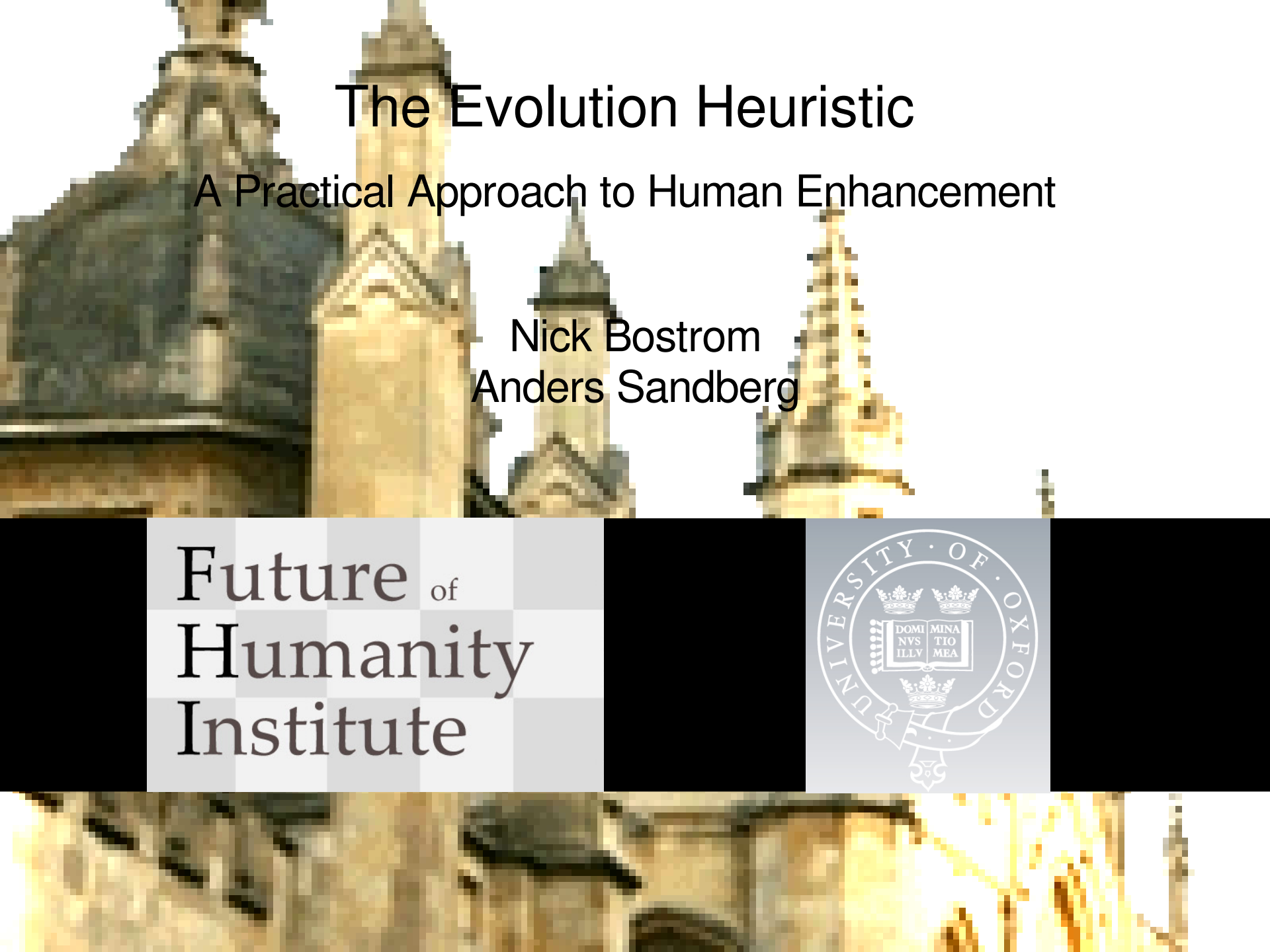


The Evolution Heuristic

A Practical Approach to Human Enhancement

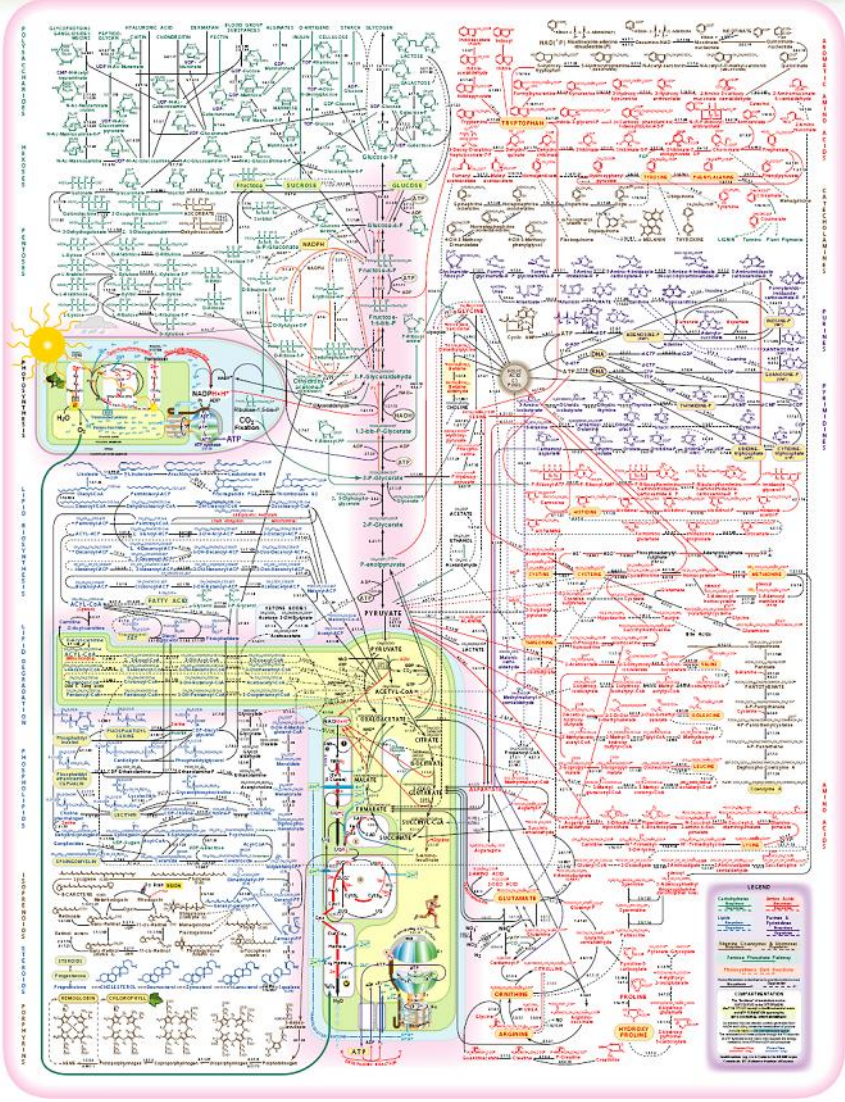
Nick Bostrom
Anders Sandberg

Future of Humanity Institute

University of Oxford

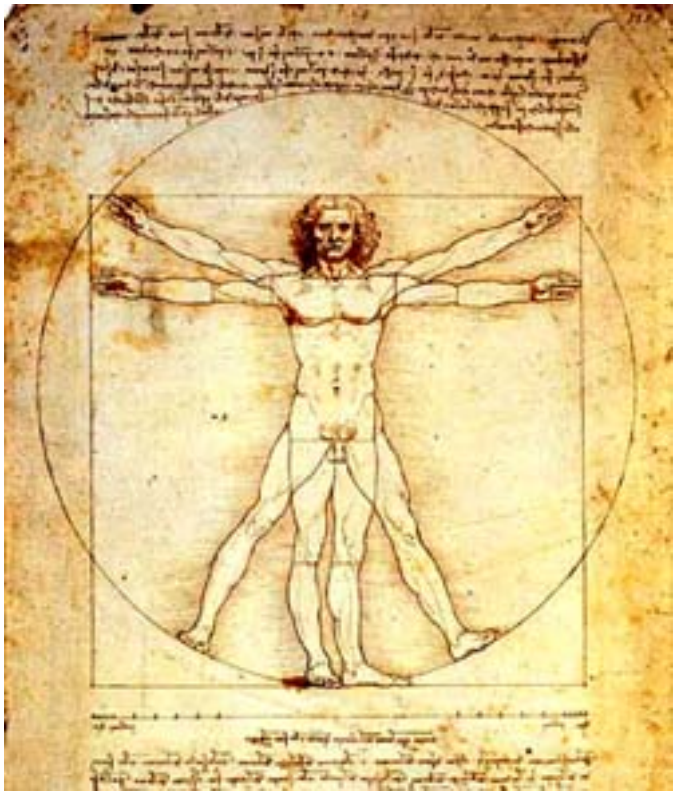
The practical challenge of enhancement

- The human organism is a marvel of complexity
- Easier to see how *therapeutic* medicine should be feasible
- Yet we know that even therapeutic medicine is very difficult
- Evolution is a process powerful enough to have led to the development of systems that are *far* more complex and capable than anything that human scientists of engineers have managed to design
- How could we realistically hope to do *better*?



Natural = Good?

- Widespread intuition that “nature knows best”
- Heuristic shows this contains grain of truth
- But also shows the limits where this intuition ceases to be valid



Definition of enhancement

- We can conceive of a proposed enhancement as an ordered pair (α, A), where α is some specific intervention (such as the administration of a drug) and A is the trait we hope that the intervention will realize (e.g. improved memory consolidation).
- Define an enhancement as an improvement in the functioning of some subsystem (e.g. long-term memory) beyond its normal healthy state, or as the addition of a new capacity (e.g. magnetic sense)
- On this definition, an enhancement is not necessarily desirable, either for the enhanced individual or for society

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?
- A. The proposed intervention would *not* have increased fitness in the environment of evolutionary adaptedness (EEA) for our species.
- B. The proposed intervention *would* have increased fitness in the EEA.

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?
- A. The proposed intervention would *not* have increased fitness in the environment of evolutionary adaptedness (EEA) for our species.
  - (EOC) Q2. *Why* would the proposed intervention not have increased fitness in the EEA?
- B. The proposed intervention *would* have increased fitness in the EEA.
  - (EOC) Q3. If the proposed intervention *would* have increased fitness in the EEA, then why did we not already evolve the enhancement which we think the intervention will produce?

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?
- A. The proposed intervention would *not* have increased fitness in the environment of evolutionary adaptedness (EEA) for our species.
  - (EOC) Q2. *Why* would the proposed intervention not have increased fitness in the EEA?
- B. The proposed intervention *would* have increased fitness in the EEA.
  - (EOC) Q3. If the proposed intervention *would* have increased fitness in the EEA, then why did we not already evolve the enhancement which we think the intervention will produce?

Non-fitness increasing enhancements

1. *A* is fitness-negative
   - volitional sterility
2. *A* is fitness-neutral
   - eye and hair color?
   - some aspects of aging?
3. *A* is intrinsically associated with another trait *B* that is fitness-negative
   - increased muscle strength might be intrinsically associated with the trait of larger muscle volume
   - increased mental activity might be intrinsically associated with the trait of increased energy consumption by the brain
4. Intervention *α* causes not only *A*, which is fitness-positive, but also, as a side effect, another trait *B* that is fitness-negative
   - anabolic steroids cause increased muscle strength but also virilisation in females, aggression, cardiovascular risks, fertility problems and increased risk of cancer
5. Intervention *α* does not produce *A*
   - “healing” pearls and crystals
6. None of the above seems to apply
   - sleep reduction?
   - increased antioxidant activity?

Non-fitness increasing enhancements

1. *A* is fitness-negative
   - volitional sterility
2. *A* is fitness-neutral
   - eye and hair color?
   - some aspects of aging?
3. *A* is intrinsically associated with another trait *B* that is fitness-negative
   - increased muscle strength might be intrinsically associated with the trait of larger muscle volume
   - increased mental activity might be intrinsically associated with the trait of increased energy consumption by the brain
4. Intervention *α* causes not only *A*, which is fitness-positive, but also, as a side effect, another trait *B* that is fitness-negative
   - anabolic steroids cause increased muscle strength but also virilisation in females, aggression, cardiovascular risks, fertility problems and increased risk of cancer
5. Intervention *α* does not produce *A*
   - “healing” pearls and crystals
6. None of the above seems to apply
   - sleep reduction?
   - increased antioxidant activity?

Changed tradeoffs

- Resources
  - The Brain…
  - The Immune system… (Placebo effect? DNA repair?)
- Demands
  - Literacy, numeracy, programming skills, IQ, …
  - Concentration…
  - Dietary preferences and fat storage,…
- Interplay between resources and demands
  - Exercise
  - Addiction

Value discordance

- Good for the individual
- Good for society

Value discordance - Good for the individual

- Emotional well-being
- Freedom from severe or chronic pain
- Friendship, love, and constancy
- Long-term memory
- Mathematical ability
- Consciousness
- Musicality
- Artistic creativity and appreciation
- Literary appreciation
- Assertiveness? – but might be changing environment…
- Healthy pleasures
- Mental energy
- Ability to concentrate
- Abstract thinking
- Healthy longevity
- Social skills

Value discordance - Good for society

- Extended altruism
- Conscientiousness and honesty
- Modesty and self-deprecation
- Originality and eccentricity and independent thinking
- Civil courage
- Good knowledge and judgment about public affairs
- Empathy and compassion
- Nurturing emotions and behavior
- Just admiration and appreciation
- Self-control; ability to control violent impulses
- Sense of fairness
- Lack of racial prejudice
- Absence of propensity to abuse drugs
- Taking joy in others' success and flourishing
- Certain kinds of intellectual talents…
- Healthy longevity

Non-fitness increasing enhancements

1. *A* is fitness-negative
   - volitional sterility
2. *A* is fitness-neutral
   - eye and hair color?
   - some aspects of aging?
3. *A* is intrinsically associated with another trait *B* that is fitness-negative
   - increased muscle strength might be intrinsically associated with the trait of larger muscle volume
   - increased mental activity might be intrinsically associated with the trait of increased energy consumption by the brain
4. Intervention *α* causes not only *A*, which is fitness-positive, but also, as a side effect, another trait *B* that is fitness-negative
   - anabolic steroids cause increased muscle strength but also virilisation in females, aggression, cardiovascular risks, fertility problems and increased risk of cancer
5. Intervention *α* does not produce *A*
   - “healing” pearls and crystals
6. None of the above seems to apply
   - sleep reduction?
   - increased antioxidant activity?

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?
- A. The proposed intervention would *not* have increased fitness in the environment of evolutionary adaptedness (EEA) for our species.
  - (EOC) Q2. *Why* would the proposed intervention not have increased fitness in the EEA?
- B. The proposed intervention *would* have increased fitness in the EEA.
  - (EOC) Q3. If the proposed intervention *would* have increased fitness in the EEA, then why did we not already evolve the enhancement which we think the intervention will produce?

The Evolutionary Optimality Challenge

- (EOC) Q1: If we the proposed intervention would result in an enhancement, why then have we not already evolved to be that way?
- A. The proposed intervention would *not* have increased fitness in the environment of evolutionary adaptedness (EEA) for our species.
  - (EOC) Q2. *Why* would the proposed intervention not have increased fitness in the EEA?
- B. The proposed intervention *would* have increased fitness in the EEA.
  - (EOC) Q3. If the proposed intervention *would* have increased fitness in the EEA, then why did we not already evolve the enhancement which we think the intervention will produce?

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

Intervention *α* does not produce *A*, or evolution is fundamentally incapable of producing *α*.

- Biology is limited in what it can build
  - diamond
  - silicon chips

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

Evolution is trapped in a local optimum

- Polygenic traits…
  - the human appendix
- Antagonistic pleiotropy
- Heterozygote advantage
  - type I Gaucher's Disease
- Evolutionarily stable state
  - e.g. due to sexual selection
- Intragenomic conflict
  - meiotic drive, transposons, homing endonuclease genes, B-chromosomes, plasmids, …

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

Fitness-increasing enhancements

1. Intervention α does not produce A, or evolution is fundamentally incapable of producing α.
2. Evolution is trapped in a local optimum
3. There is an evolutionary lag
   - Enhancement lags behind, no alternative way
   - Enhancement lags and there exist alternative
   - Enhancement not lagged

There is an evolutionary lag

- A wide range of variation in salt-regulating genes in populations far from the equator
- Genes involved in brain development have been shown to been under strong positive selection with new variants emerging over the last 37,000 years
- Lactose intolerance

Take-home message

- Human organism extremely complex

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult
- When could we expect to benefit from tinkering with the work of the Great Engineer?

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult
- When could we expect to benefit from tinkering with the work of the Great Engineer?
  - We could adapt the system to a new environment

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult
- When could we expect to benefit from tinkering with the work of the Great Engineer?
  - We could adapt the system to a new environment
  - We might have tools that the Great Engineer lacked

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult
- When could we expect to benefit from tinkering with the work of the Great Engineer?
  - We could adapt the system to a new environment
  - We might have tools that the Great Engineer lacked
  - We might try to achieve something the Engineer didn't *want* to do

Take-home message

- Human organism extremely complex
- Evolution pretty good engineer
- Enhancement in general difficult
- When could we expect to benefit from tinkering with the work of the Great Engineer?
  - We could adapt the system to a new environment
  - We might have tools that the Great Engineer lacked
  - We might try to achieve something the Engineer didn't *want* to do