

# **Big Issues at the (Very) Small Scale: Ethical and Social Implications of Nano-Neurotechnology**

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# Nanoscience

## ■ Stand-alone Discipline

- Distinct investigations at nanoscale
- Applications of nanoscale devices

## ■ Technologic Tool(s)

- Allow scalar dimensions to facilitate
  - Properties
  - Access
  - Platforms

# Neuroscientific Applications

- **Direct Nervous System Access**
  - Nano-neuropharmacology
    - High bioavailability hormetic responses/effects
  - Nano-neurostructural components
    - Nano-orthotics
    - Nano-prosthetic networks

# Neurotechnologic Synergy

- **Ligand platforms**
  - Complete low dose ligand carriers
  - Molecular assemblage(s)
  - Enzymatic synthetic arrays
- **Neuro-nanobots**
  - Intracellular access and manipulators
  - Molecular manipulators
- **Nano-device/neural interfaces**
  - Recording networks
  - Input networks
- **Structural cybernetic arrays/networks**
  - Autopoietic component assemblies

# Benefits

- **Driving maxim of achieving “good”**
- **Facilitates/permits:**
  - **Dimensional/scalar accessibility**
    - Heretofore impossible access to biologic compartments
    - Potentiation of endogenous system function(s)
  - **Sub- and suprascalar technologic linkage(s)**
    - Bridge to femtoscale applications
    - Bridge to indwelling and external multi-scale technologies
    - Moore’s Law-based expansion(s)

# Burdens and Risks

- **Wexelblatt's Law:** "Nature has a nasty sense of humor"
  - Unknowns at nano scale and properties
  - Up- and down-stream effects of complex systems' dynamics
- **Possible "runaway" consequences**
  - Un-knowables at new frontier(s) of the unknown ("footfall effects"; "tripping hazards")

# Burdens and Risks

## ■ Social Diffusion

- New/novel social classifications
- Ontologic effects

## ■ Purloinment

- Whose “good”, by what definition?
- Technologic imperatives dictated by Market, Politics

# Implications

- **Public Health Risk(s)**
  - Loss of control
  - Wexelblatt Effects
- **Social Issues**
  - Justice: commutative and distributive
  - Autonomy Issues: independence
- **Security/Defense Issues**
  - Nanoneuro Assessment
  - Nanoneuroweapons



# Critical Balance

Progress – Potential – Problems-  
Public Protection – Personal Privacy

## ■ Simple Precautionary Principle?

- i.e.- If risk > benefit, then stop
- Not entirely applicable...

*Why?*

- **Status quo is Progress:** Conditions are risky at the frontier/boundaries of known, unknown, unknowable

# What NOT to do...



# Goal

- Not to simply retard progress....
- Rather, assume Arendtian stance:
  - Need to mitigate non-contemplative advancement (i.e.- *animal laborens*)
  - Instantiate reflective analyses before and during technologic development and use  
(i.e.- *Homo faber*)

# How?

1. Recognize the boundaries and frontiers

“...the new is always unpredictable”

2. Recognize/appreciate that conditions at the boundaries/frontiers may be 'different'

3. Weigh and balance optimism, pessimism and pragmatism

# Establish Groundwork Questions

1. What are the risks (known and possible)?
2. Are there unique ethical, legal, social issues?
3. What risk- and ethical assessments can be used?
4. How do (novel) situations militate which risk- and ethical approaches should be used?

# Risk- and Ethical Management Paradigm

## 4Ps:

### ■ **Precautionary**

- acknowledging status quo involves progress

### ■ **Personnel**

- perceptive
- pragmatic
- persistent

### ■ **Predictions**

- possibilities
- problems: containable, retrievable, reversible and/or forgivable?

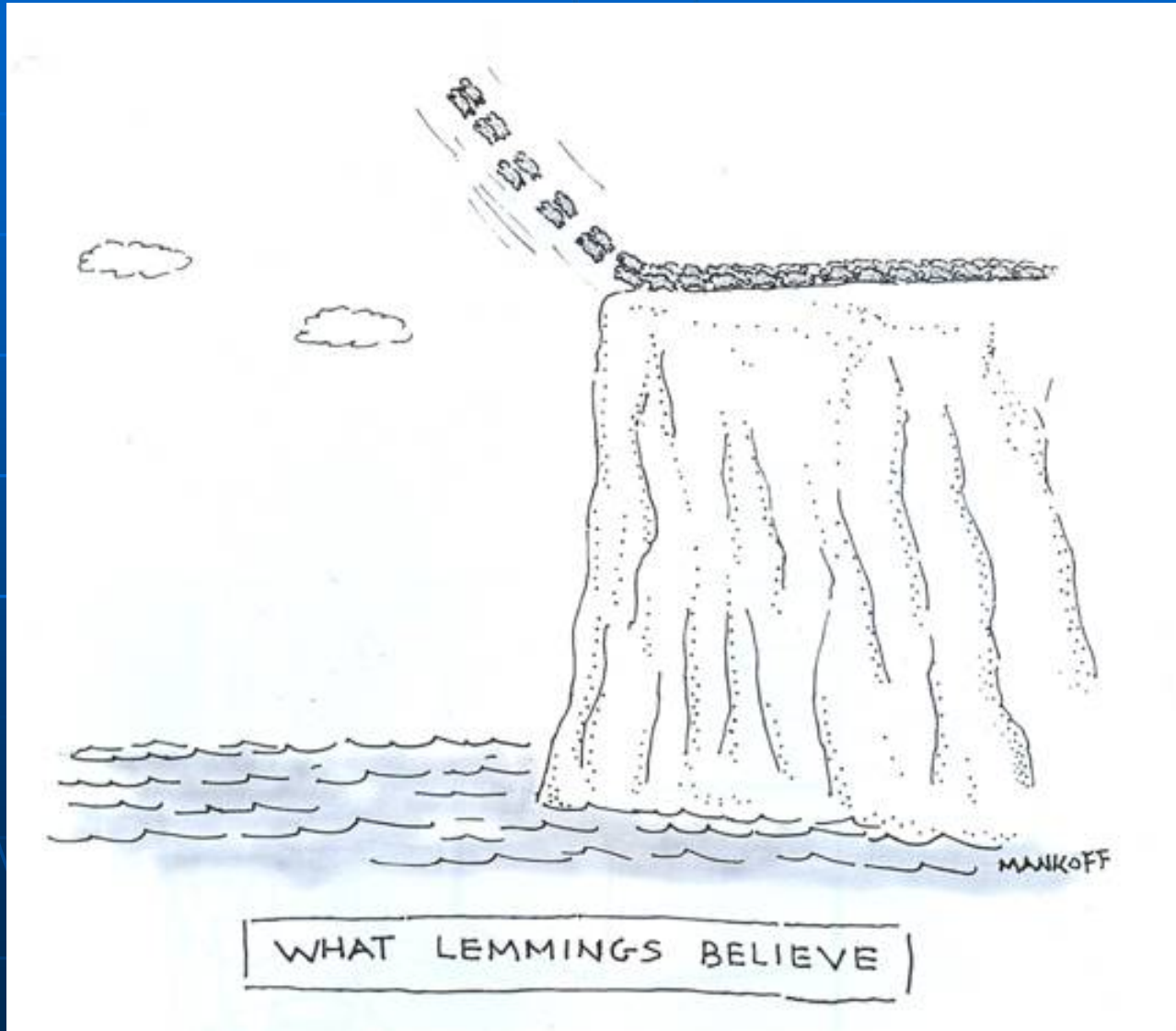
### ■ **Policies**

# “Precautionary Process”

## Game Theory in Praxis

- Identify risk scenarios that evolve from specified events
- Craft strategies for preemption, preparation, response, and amelioration
- Examine (setting, exploring, and exploiting) conditions at the operational level, across all elements, and the physical, cognitive and informational domains
- Create strategies that are relevant, durable, and can be targeted for demographics and psychographics in the face of severe cultural impact
- Identify/plan a robust framework to remain effective and adaptive to a changing environment as risks and society (co-)evolve.

**“Where might we be going?”**





**Reflection, insight and moral  
pause must precede and  
accompany all future acts of  
inquiry, invention and  
intervention...**

**“Measure twice, cut once”, for all too  
often, there is no turning back.**

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