



# A Hygiene of Life

## Doing Science in a Pluralistic Society

Doing Science in a Pluralistic Society

# What Is Science?

- The scientist aims at a true description of the world, and at a true explanation of observable facts
- The scientist can never know for certain whether her findings are true, although she may sometimes establish with reasonable certainty that a theory is false
  - Karl Popper, *Conjectures and Refutations* (1963)

# What Is Science?

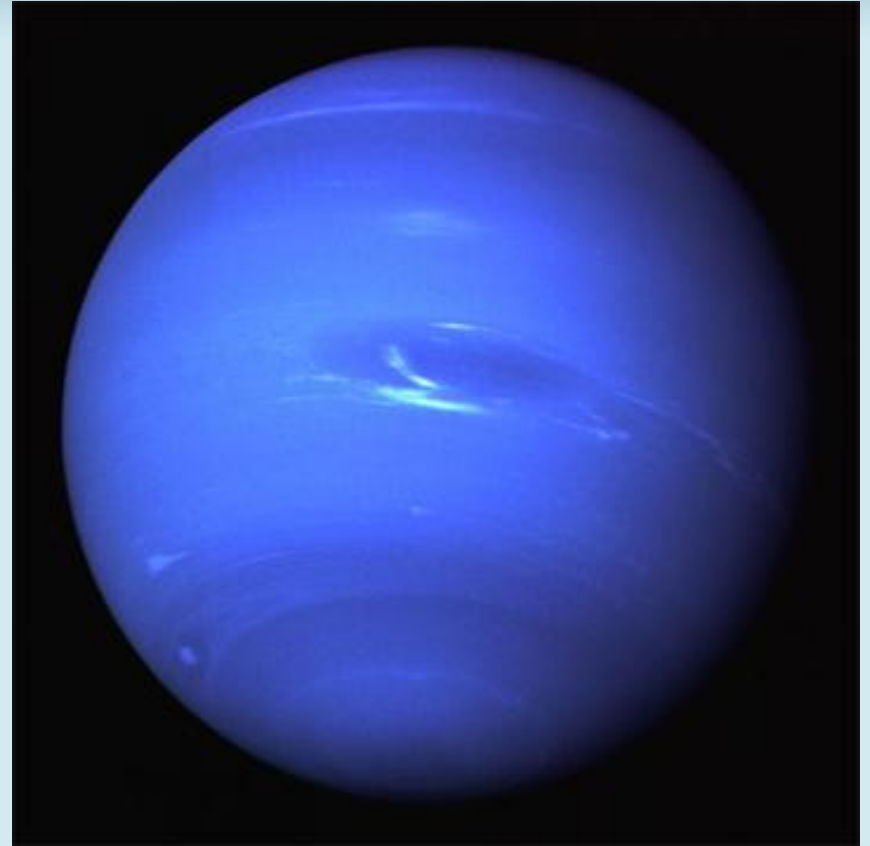
- It would be a grave mistake to conclude that the uncertainty of a theory diminishes in any way its *claim* to describe something real
  - Karl Popper, *Conjectures and Refutations* (1963)

# What Is a Good Theory?

- Backed by a considerable amount of independent experimental evidence

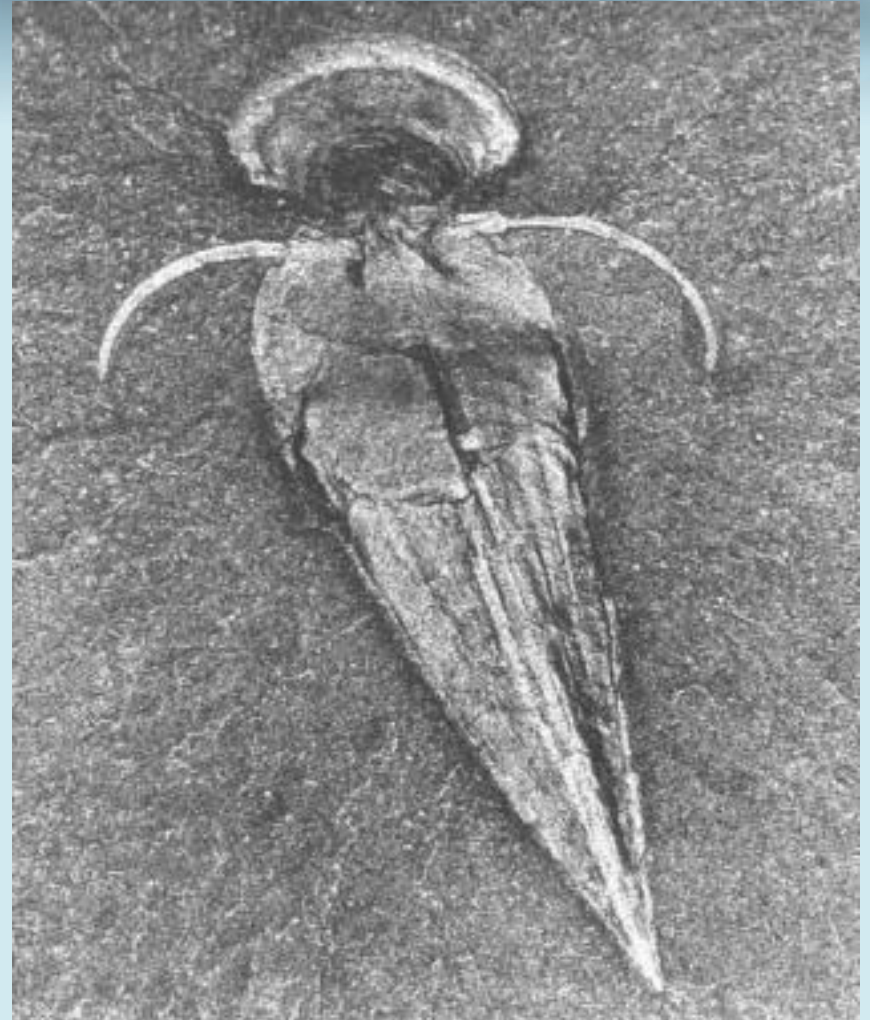
# What Is a Good Theory?

- Proved to have explanatory and predictive capacities
  - Newton's Theory of Gravitation



# What Is a Good Theory?

- Predictions of yet unobserved facts can be derived from the theory
  - Discovery of Cambrian explosion predicted by Darwin's Theory of Evolution



# What Is a Good Theory?

- Offers clear-cut problems for further research
  - Ludwig von Bertalanffy, *General System Theory* (1968)

# What Is Science?

“Yet with how many things are we upon the brink of becoming acquainted, if cowardice or carelessness did not restrain our inquiries.”

— Mary Shelley,  
*Frankenstein*





# What Is Science?

“There are many different ends that men may seek and still be fully rational, fully men, capable of understanding each other and sympathizing and deriving light from each other, . . . worlds, outlooks, very remote from our own.”

— Isaiah Berlin, *The Pursuit of the Ideal*

“Questions of use of science and technology are always moral and political questions, never simply technical ones.”

— Leon Kass, *The New Biology: What Price Relieving Man's Estate?*

# What Is Ethics?

- Values relating to human conduct
- Rightness or wrongness of certain actions
- Goodness or badness of the motives and ends of such actions
- The science of morals

# What Is Ethics?

- Immanuel Kant's *Formula of Humanity as an End in Itself*
  - “So act that you use humanity . . . always at the same time as an end, never merely as a means”
- Kant's *Categorical Imperative*
  - “Act only in accordance with that maxim through which you can at the same time will that it become a universal law”

# What Is Ethics?

- Ethics is a *doctrine of action*
- Metaphysics is a *doctrine of being*, in which all ethics must ultimately be grounded
  - Hans Jonas, *Technology and Responsibility: Reflections on the New Tasks of Ethics*. In: *Philosophical Essays: From Ancient Creed to Technological Man* (1974)

# What Is Ethics?

- Act so that the effects of your action are compatible with the permanence of genuine human life
- Do not compromise the conditions for an indefinite continuation of humanity on earth
  - Hans Jonas, *Technology and Responsibility: Reflections on the New Tasks of Ethics*. In: *Philosophical Essays: From Ancient Creed to Technological Man* (1974)

# Should We Do This Research?

- Should life rule over knowledge and science, or should knowledge rule over life?
- Science needs the supervision and surveillance of a higher power; a *hygiene of life* occupies a place close by the side of science . . .
  - Friedrich Nietzsche, *Untimely Meditations: On the Uses and Disadvantages of History for Life* (1874)

# Bioethical Principles

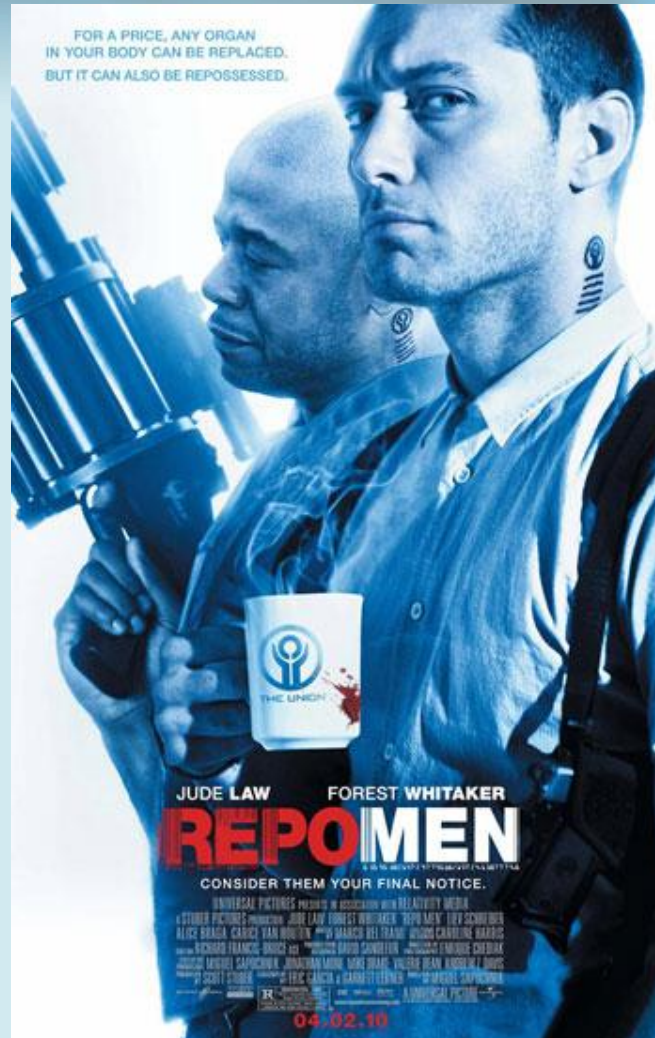
- Autonomy
- Beneficence
- Nonmaleficence
- Justice

# South Carolina Project for Organ Biofabrication

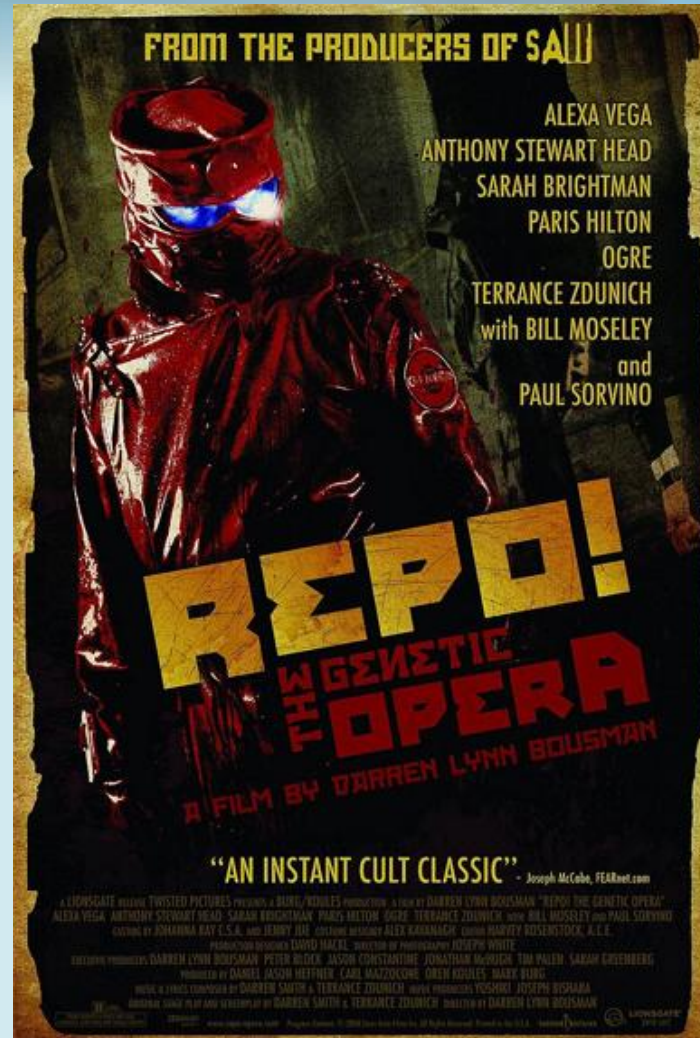
- Bioprinting — radical technology
  - Jet-based 3D tissue engineering
    - Layer-by-layer deposition of matrix and cells
  - Combines developmental biology, tissue engineering, and materials science
  - Leverage stem cell research
    - Induced pluripotent stem cells



# Organ Biofabrication in the Collective Unconscious



# Organ Biofabrication in the Collective Unconscious



# Organ Biofabrication

- Industrial production of organs for transplantation
  - U.S. DHHS Organ Procurement and Transplantation Network
    - 109,000 waiting list candidates
      - 86,000 kidney waiting list
      - 16,000 liver waiting list
    - 17,000 transplants performed, January to July 2010

# Organ Biofabrication

- *In vitro* disease models
- Drug discovery
- Biofuel development
- “Animal-free” food

# Organ Biofabrication — Ethical Issues

- “Commercially successful biofabrication industry”
  - \$\$ means trouble
    - GlaxoSmithKline \$750 million settlement
      - *The New York Times*, 10-28-2010
- Novel life-forms
- Post-humans

# Organ Biofabrication — Ethical Issues

- Distributive Justice
  - Access
  - Affordability
  - Covered service?
  - Lottery system?

# South Carolina Project for Organ Biofabrication — Communicating Science to Society

- Strategic Plan 2009–2014
  - Broaden public understanding of organ biofabrication
    - NEED — broaden public understanding of *science*
  - K-12 classrooms
  - Train non-specialist journalists
  - Educate elected officials

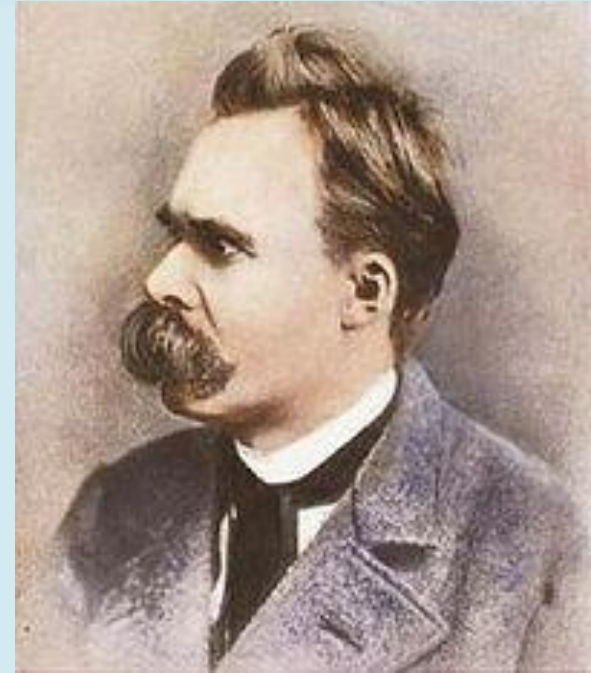
# The Nature of Science

- Progress of science cannot be predicted
- All scientific experimentation is potentially world-changing
- New scientific developments often have novel and unanticipated applications



# Should We Do This Research?

- “Is there knowledge which should not be pursued because it is noxious to life?”  
—Friedrich Nietzsche  
(1844–1900)



# Science and Regulation

- “In the long run, our hope can only lie in education: in a public educated about the meanings and limits of science and enlightened in its use of technology”
  - Kass LR: The new biology. What price relieving man’s estate? Science 174(4011):779–788, 1971

# Five Grand Challenges to Science and Society

- Energy
- Environment
- Economics and Equality
- Education
- Ethics

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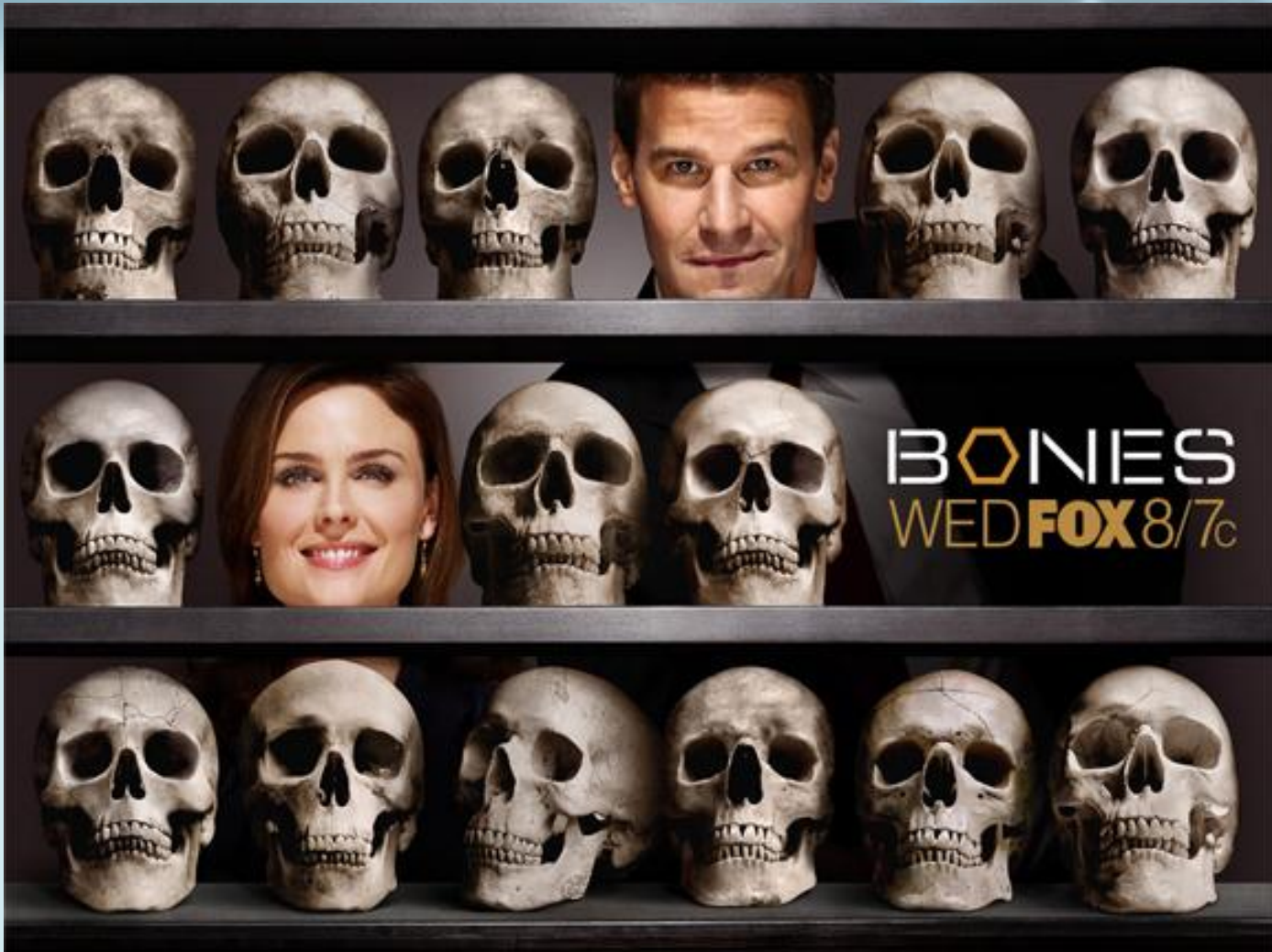
- We fail to provide the basic necessities for 1 out of 5 people on earth today
- Currently, 7.6 million infants – mostly in developing countries – die in their first year of life
- 46 countries have lower infant mortality rate than the U.S.
- U.S. has the highest teenage birth rate of any developed country

# Five Grand Challenges to Science and Society

- Environmental stresses
  - Infectious diseases
  - Biodiversity losses
  - Loss of tropical forests
  - Fisheries depletion
  - Increasing water scarcity
  - Pollution of the seas
  - Climate change

# Five Grand Challenges

- Cost about \$60 billion per year to provide universal access to basic services
  - Clean water
  - Sanitation
  - Education
  - Family planning



# BONES — 10/14/2010 Episode — The Science Dude

- The Code of the Scientist
  - Observe
  - Analyze
  - Deduce
- It's not magic — it's SCIENCE!



# BONES — The Science Dude

- The Scientist's Oath
  - We see big stars; tiny atoms, too
  - We get the facts; and say what's true
  - We use our minds; embrace what's new
  - Because that is what scientists do!