BIO 5099: Molecular Biology for Computer Scientists (et al)

Lecture 26: Biology and Society

http://compbio.uchsc.edu/hunter/bio5099
Larry.Hunter@uchsc.edu
Molecular biology (and biotechnology) will lead to explosive changes in the world.

- Today, we discuss some of the ways that the topics we studied this semester will have broader social implications

The materials in this class can help you understand (and maybe effect) these changes.

- The privilege of knowledge brings with it a responsibility to use that knowledge for the good of the society that created it and made it possible for you to learn it.
The role of knowledge in action

The World

Issues

Predictions

Intervention

Human action & decision-making processes

Outcomes

Values

Knowledge: recognition, prediction, engineering, planning
This class...

Will raise some of the issues around biology that I believe are likely to confront us.

Is shaped by my values (particularly in the choices about what to include and not), but attempts to be reasonably value neutral.

- Which means no prescriptions for what to do...

May lead to conflicts based on differing values

- So I will try to lead us away from discussions about what we should do, and towards understanding some of the challenges that may confront us.
Change is coming

Compare the revolution in molecular biology with the advent of information technology:

- MolBio is **half as far along** as IT
  - First stored program computer: 1946 (56 years ago)
  - First recombinant DNA: 1974 (28 years ago)
- The social import of applications seems in many ways **more fundamental to what it is to be human**:
  - IT: Communication, Banking/Finance, Commerce(?)...
  - Biology: Food, Health/Medicine, Reproduction
- Challenges are different:
  - IT: Infrastructure fragility, privacy invasion, alienation?
  - Bio: novel diseases, genetic pollution, germline change
Some MolBio & Society issues

- Biotechnological Problems
  - Predictive/Personalized Medicine and US Health Care
  - Genetic pollution
  - Biowarfare

- How to value life
  - Biodiversity and mass extinction
  - Lifeform patents

- What it is to be alive, and be human
  - The status of engineered organisms
  - Issues around genetic engineering and humanity

- The precautionary principle
  - How (and whether) to capture uncertainty in policymaking
Even good things present challenges

Imagine that the promise of genomic medicine is largely fulfilled:

- **Predictive**: tests for particular polymorphisms lead to accurate predictions of future disease.
- **Personalized**: drugs and other therapies are prescribed on the basis genetic polymorphisms (*pharmacogenomics*)

The current health care system is very poorly suited for taking advantage of this promise:

- Curative, not preventive medicine (insurers won't pay to save costs in the future if people can change insurance)
- Development costs recouped by many uses (blockbusters)
The transmission of engineered genes to organisms other than the intended recipients

- Many transgenic organisms will be released, through agriculture, bioremediation, accidents, etc.
- The organisms can interbreed with wildtypes and genes may be exchanged through horizontal transmission

Possible consequences:
- Pests gain resistance genes (e.g. to antibiotics, herbicides or pesticides)
- Modified organisms outcompete others, forcing extinctions
- Unpredictable consequences of novel gene combinations
Pollution abatement?

Gene flow in realistic situations not well understood, but currently under study:
- Plasmid exchange and drug resistance
- Cross-pollination among crops and surrounding plants

Political responses:
- Ban of all recombinant DNA research in Mexico
- Bans of genetically modified crops in European countries

Market responses:
Biological Warfare

Ancient and very effective
- From distribution of smallpox laden blankets to native Americans, to (unsolved) anthrax attack on US last fall.
- No known uses that involved molecular biotechnology

Molecular biotechnology allows new twists
- Synthesis of poliovirus from inorganic materials
- Understanding mechanisms of pathogenicity and infection may lead to engineered approaches
- Developing immunization along with pathogen more likely
- Equipment and skills are becoming widespread
As we discussed early in class, there is overwhelming evidence of a contemporary anthropogenic mass extinction event.

Many issues
- How to value biodiversity?
- Any intrinsic value to the lost species themselves?
- Instrumental values of lost species, e.g. as sources of valuable genes/gene products.
- How to address biodiversity loss: endangered species laws, habitat preservation, cataloging/sampling?
- Who pays? Debt-for-nature swaps, bioprospecting rights
Patenting Lifeforms

Patents on life:
- Originally denied, due to “product of nature” doctrine.
- 1930 Plant Patent Act allowed patenting of plants that were reproduced asexually (“product of breeders”)
- 1972 Chakrabarty applies for patent on oil-eating bacterium (plasmid), Supreme Court agrees in 1980
- 1983 First animal patent, the Harvard Oncomouse.
- 1999 Human chimeric patents (Rifkin & Newman)

Patents on genes:
- Alpha interferon was first in 1980; still lawsuits ongoing.
- Many patents without knowledge of function!
Now, 'human' is a privileged class, and the boundaries are clear (sort of).

- But definitions of human recently involved gender and race

Transgenic animals may have increasingly human aspects

- Xenotransplantation and organ farming
- (Speculatively) suppose language depended on 10 genes that could be transfected into other primates, and the recipient organisms claimed human status?
Changes in Humans

If gene therapy becomes safe and effective, it is likely to spread broadly
- Dividing line between curative and performance enhancing is very hard to make, let alone enforce.
- Differences in phenotype can rapidly become extreme

Germline therapy is likely to follow
- Technically very little difference from somatic therapy
- Only way to cure developmental abnormalities
- Hard to deny parents rights to possible cures for children

Consequences could be dramatic; speciation?
Already identified challenges

Human Genome Project included 3-5% set as side for related “ethical, legal, and social issues” (ELSI) research.

- World's largest ever bioethics project

Identified 9 areas of “Societal concern arising from the new genetics”

- We will look at each very briefly
ELSI issues (1-3)

Fairness in the use of genetic information by insurers, employers, courts, schools, adoption agencies, and the military, among others.
- Who should have access to personal genetic information, and how will it be used?

Privacy and confidentiality of genetic information
- Who owns and controls genetic information?

Psychological impact and stigmatization due to an individual's genetic differences.
- How does personal genetic information affect an individual and society's perceptions of that individual?
- How does genomic information affect members of minority communities?
Reproductive issues including adequate informed consent for complex and potentially controversial procedures, use of genetic information in reproductive decision making, and reproductive rights.

- Do healthcare personnel properly counsel parents about the risks and limitations of genetic technology?
- How reliable and useful is fetal genetic testing?
- What are the larger societal issues raised by new reproductive technologies?
Clinical issues including the education of doctors and other health service providers, patients, and the general public in genetic capabilities, scientific limitations, and social risks; and implementation of standards and quality-control measures in testing procedures.

- How will genetic tests be evaluated and regulated for accuracy, reliability, and utility? (Currently, there is little federal regulation.)
- How do we prepare healthcare professionals for the new genetics?
- How do we prepare the public to make informed choices?
- How do we as a society balance current scientific limitations and social risk with long-term benefits?
Uncertainties associated with gene tests for susceptibilities and complex conditions (e.g., heart disease) linked to multiple genes and gene-environment interactions.

- Should testing be performed when no treatment is available?
- Should parents have the right to have their minor children tested for adult-onset diseases?
- Are genetic tests reliable and interpretable by the medical community?
Conceptual and philosophical implications regarding human responsibility, free will vs genetic determinism, and concepts of health and disease.

- Do people's genes make them behave in a particular way?
- Can people always control their behavior?
- What is considered acceptable diversity?
- Where is the line between medical treatment and enhancement?

Health and environmental issues concerning genetically modified foods (GM) and microbes.

- Are GM foods and other products safe to humans and the environment?
- How will these technologies affect developing nations' dependence on the West?
Commercialization of products including property rights (patents, copyrights, and trade secrets) and accessibility of data and materials.

- Who owns genes and other pieces of DNA?
- Will patenting DNA sequences limit their accessibility and development into useful products
The Precautionary Principle

If there are reasonable scientific grounds for believing that a new process or product may not be safe, it should not be introduced until there is convincing evidence regarding its risks and benefits.

Highly controversial (mostly US vs. Europe)

- US: Can never prove safety; hypothetical risks are endless; innovation is an important value in itself
- Europe: Easier to prevent a problem than to remediate; some potential problems cannot be remediated, only prevented.
Life is extraordinarily rich and beautiful, all the way down to its molecular mechanisms.

Although life has been an object of human study for thousands of years, recent access to molecular phenomena have yielded profound insights into many of life's mysteries.

- And still so much remains mysterious...

We are on the threshold of tremendous change in the living (and human) world.

- Better knowledge of all aspects of life will be of great value.