Lecture Notes for Honors Biology 350: Biology and Society

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Introduction

The goals of this course are:

1. To introduce and reinforce an understanding of the nature of science

2. To introduce and analyze the relationship between professional science and the general public in America

Dramatic changes have occurred in the relationship between professional science and the American public since World War II. What have these changes produced? What is the relationship today between science and society in America?

3. To introduce the major secular ethical systems of thought

It is necessary that we cover the traditional secular systems of ethical philosophy at the beginning of a course of this type. Consequentialism and utilitarianism are the traditional ethical systems available for a public discussion of ethics. However, mediational or provisional ethics may provide the best compromise of values for a public and secular system of ethics in our world today.

4. To introduce and discuss some of the major social, ethical issues that exist between science and society in America today

The Course Structure

The framework for the course consists of the following elements:

A) The introduction which consists of three parts:

Unit One: The Nature of Science

- Defining Science
- The Epistemic Values of Science
- Science as a Profession

Unit Two: The Relationship between Science and Society

- What does the general public think about science?
- Why does our society support science?

Unit Three: Ethical Philosophies

- The Relationships between science and philosophy
- The Divisions of Ethics
- Traditional Ethical Theories
- Public Ethics in a Pluralistic Society

B) The remainder of the course consists of topics relevant to the relationship between science and society today. Their order of presentation has been organized using Peter Singer's concept of an expanding circle of ethical responsibility. The first topics presented relate to the individual and the family. The following topics then expand the ethical relationships to the community, the state, and, finally, the world.

Major Topics covered in the Course

Unit Four: Genetics and Medicine

- A Primer on Human Genetics
- Genetic Screening
- The Human Genome Project

Unit Five: Human Reproduction

- Embryogenesis and Development
- Prenatal Care
- Conception control and Birth control
- Assisted Reproductive Technologies (ART)
- Gender Selection
- Stem Cell Research
- Cloning Humans
- Genetic Engineering of the Human Gemline

Unit Six: Human Longevity

- Maximum Life Span
- Life Expectancy
- Health Expectancy
- Research on Aging

Unit Seven: The Human Impact on the World

- History of Human Population Growth
- How many people can the Earth support?
- Biodiversity

Unit Eight: Ethics and Equity in the 21st Century

C) Each of these topics is divided into two parts.

1. What is the scientific knowledge needed to address the topic?
2. What are the central ethical issues involved in the topic?

Unit One: The Nature of Science

Defining Science

1) As a set of rules for how to look at the world

The Epistemic Values of Science

2) As a very human activity with all of the attendant failings

Science as a Profession

3) As the product of the activity of science

Scientific Knowledge

Science and Epistemic Values

"Against the background presumption that our aim is to understand the world of experience, a world of unbroken regularity, these values are tools or standards that we cherish, since 'they are presumed to promote the truth-like character of science, its character as the most secure knowledge available to us of the world we seek to understand' Hence, an 'epistemic value is one we have reason to believe will, if pursued, help toward the attainment of such knowledge.'" (McMullin 1983; Ruse 1996)

Terms and Definitions to Know

Epistemology—the systematic investigation of the origin, nature, methods, and limits of human knowledge. It attempts to answer the question, "how does the human mind perceive and know what is outside itself?" (Bronowski 1960)

Descriptive—that about a phenomena that can be proven or verified by experience or experiment; descriptive statements are empirical observations subject to scientific verification.

Descriptive Epistemology—empirical observations on how we actually view the world.

Prescriptive—that which gives direction or rules; prescriptive statements are statements of what we should do to achieve specific goals.

Prescriptive Epistemology—rules for how we should view the world that are based upon more fundamental epistemological assumptions.

Epistemic Values—are prescriptive epistemological values that serve in achieving a specific goal. In science that goal is to produce reliable knowledge of the natural, physical world.

The Epistemic Values of Science

1) Only those claims to knowledge where the underlying physical causes of a phenomenon have been shown can be accepted by science. This requirement that the cause and effect mechanism that produces a phenomenon must be demonstrated is called **skepticism**. Methodological skepticism requires that all underlying assumptions of a claim to knowledge be identified and their validity questioned. The philosopher David Hume in his *Treatise on Human Nature* (1740), is credited with being the first to show the importance of skepticism in epistemology.

2) Only knowledge claims based upon **physical evidence** can be a part of science. The corollary of this is that all knowledge claims based upon authority alone must be rejected. Personal beliefs do not support claims to knowledge in science. This reliance on physical evidence is closely tied to the rejection of the "scholastic tradition" of accepting the word of authority as absolute truth which began in the Renaissance and continued on through the Reformation with the rejection of the authority of the Catholic Church.

3) **Prediction** by itself is insufficient to support knowledge claims. Correlation by itself fails to link cause to effect. What is needed is an understanding of the mechanism by which a given phenomenon is produced. This is reflected in science by the value placed on skepticism. But if prediction is combined with a coherence to the sum of our reliable knowledge of the physical world, successful prediction in science does support knowledge claims.

4) **Coherence** is the logical connections between the elements of a set of concepts and facts; the degree of coherence that a set of concepts and facts has is a measure of its internal, logical consistency. In science all concepts and scientific facts must cohere to all other scientific facts and concepts; they must be both internally and externally, logically consistent.

5) **Consilience**, as a property of scientific theories, increases the reliability of scientific claims to knowledge. The degree that a scientific theory has consilience is a measure of its ability to explain and unify many separate and seemingly unrelated areas of scientific study. Consilience presupposes the unity of knowledge that follows from the assumptions of realism. That is, if there is only one real world, then all true knowledge will be coherent and contribute to understanding that world. The term consilience was first used by William Whewell in 1840.

Epistemic Values and the Origin of Modern Science

The origin of modern science can be established by locating when the shift toward the epistemological values of modern science began. This shift in values has been defined most clearly by the late Jacob Bronowski. “I hold that the scientific revolution from 1500 onward was an essential part of the Renaissance,”

“Since that time we have been in the unique position of trying to form a single picture of the whole of nature including man. That is a new enterprise; it differs from the preceding enterprises in that it’s not magical, by which I mean that it does not suppose the existence of two logics, a natural logic and a supernatural logic.”

“If one had to put a date to this, [the origin of modern science] one would say that roughly speaking between 1500 and the publication of Porta’s book in 1558, which was called *Natural Magic* the turning point took place.”

“Finally came the concept of natural law itself. And that was represented, in a most spectacular way, for the first time in the writing of Francis Bacon between 1600 and 1620. It was Francis Bacon who was the first person to say ‘knowledge is power.’ It was Bacon who said in the *Novum Organum* ‘we cannot command nature except by obeying her.’” (Bronowski 1978)

Time Line for the Epistemic Values of Science

1558 -- Porta’s book *Magiae Naturalis* (*Natural Magic*) is published

1620 -- Francis Bacon “we cannot command nature except by obeying her”

1662 -- the founding of the Royal Society in England with their motto [roughly translated from Latin] “Take nobody’s word for it; see for yourself”

1740 -- David Hume on skepticism in *Treatise on Human Nature*

1840 -- the work of William Whewell on the *Consilience of Inductive Sciences*

“Science is a long history of learning how not to fool ourselves.”

Richard Feynman (1918-1988)

Science as a Profession

How is science as a profession organized today?

How does it operate to produce reliable knowledge?

How long has science been a profession?

The Organization of Modern Science

The University Connection

Foundations & Institutes -- NSF, NIH, Salk, Max Planck

Societies -- AAAS, NAS

Journals -- *Nature, Science*

The Reward System

(research / publish -- peer reviewed journals / grants / promotions / prizes)

Science as a Self-Correcting System

(You are rewarded for finding mistakes as much as you are for making new discoveries.)

The Corporate Connection

The Rise of Biotechnology

Fundamental as opposed to Directed or Applied Research

The "Motive" of Research

How can we define who is a professional scientist?

"By statured scientists I mean those who collect and analyze the data, build the theoretical models, interpret the results, and publish articles vetted [peer reviewed] for professional journals by other experts, often including their rivals."

from *Consilience: The Unity of Knowledge* by E. O. Wilson (1998)

Professional Science can be divided as follows:

Academic and Institutional Science -- consists of those scientists working in public and private institutions such as universities and institutes where the major funding for research is public monies. Publishing results in peer reviewed journals is a central goal of this research.

Corporate or Industrial Science -- consists of those scientists working for private companies or corporations where funding is provided by private investment. Publishing results is not a goal of this research.

Both Academic and Corporate Science can then be divided into:

Fundamental or Pure Research is driven by the goal of discovering new knowledge without regard to the direction the research might take.

Directed Fundamental Research has a predetermined goal that only can be achieve by the discovery of new knowledge. The cure of specific diseases such as cancer is an example of such research.

Applied Research takes existing scientific knowledge and applies it to develop new technological applications. The development of computer software produces no new scientific knowledge and yet is central to developing new applications of our existing scientific knowledge of electronic computing. Applied research is done by both professional scientists and engineers.

How old is professional science?

The creation of a profession from 1662 to 1869

Time Line for Science as a Profession

Mid 1600s -- founding of the Royal Society in England and the Academie des Sciences in Paris

1665 -- first issue of the scientific journal the *Philosophical Transactions* of the Royal Society

Early 1800s -- “France despite and because of the Revolution, was the first and most vigorous country in offering opportunities for professional scientists, in any sense that we know them today.” (Ruse 1996)

1833 -- William Whewell in England coins the term “scientist”

1869 -- founding of the scientific journal *Nature* by T.H. Huxley and friends

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T. H. Huxley (1825-1895) was the first to forge the connection between professional scientists and public education, i.e. with the training of science teachers and the link to training doctors. Huxley was also an example of the new breed of scientists who relied solely on their income earned as a professional scientist. Darwin, in contrast, was independently wealthy and did all of his research without having a professional position.

Unit Two: The Relationship between Science and Society Today

What does the general public think about science?

Is it good or bad?

Why does our society support science?

Could we do without science?

If not, what do we get by doing science?

What does the general public think about science?

The 2002, NSF survey of American adults found that 72% believe that the benefits of scientific research outweigh the harmful effects.

In contrast, only 33% of Americans understand the nature of scientific inquiry well enough to make informed judgments about the scientific basis of results reported in the media. (NSF 2002)

Estimated R&D expenditures by source, for the years 1940 and 1998

Expenditures (in millions)	Total	Industry	Federal	Universities and colleges	Other*
1940 (in 1998 dollars)............	3,617	2,453	702	325	136
Percent of total	100	67.8	19.4	9.0	3.8
1998 (in 1998 dollars)............	227,173	149,653	66,930	4,979	5,611
Percent of total	100	65.9	29.5	2.2	2.5

*Includes state governments and nonprofit institutions.
(modified from *Science & Engineering Indicators 2000*, Page 9, Text table 1-3)

Survival Value & Control

In answer to the question, "What do we get by doing science?", we have the following.

For science to exist we must want to know; we must really want to know. We must be willing to give up all our preconceived notions and beliefs and let nature be the final arbitrator of truth.

The tradeoff is that there is tremendous survival value in having reliable knowledge about our world. With it comes control over nature and for the first time in human history we are no longer at the mercy of an indifferent universe.

Freedom of Action & Control

Moral responsibility can arise only when there is freedom of action and the ability to control the outcome of relevant events. Thus, there are two aspects in assessing moral obligation. The first is that we must be free to act upon our ethical considerations. The second is that our actions must be able to change the course of events. We must be able to control the outcome of events to have moral responsibility, for no moral entity can logically be held responsible for anything that is beyond their control. Thus, *control*, itself, is the logical first principle for determining moral responsibility.

The most significant change in our world in the last four hundred years is that science and technology have immensely extended our control over natural events. This extension of control has extended our moral obligations in directions undreamed of by our ancestors. It is, therefore, the fundamental task of our age to analyze and come to understand how this extension of control over the natural world has changed our moral obligations.

Unit Three: Ethical Theory

Branches of Philosophy Relevant to Science

Epistemology—the systematic investigation of the origin, nature, methods, and limits of human knowledge. It attempts to answer the question, how does the human mind perceive and know what is outside itself?

Ontology—is concerned with the nature and relations of being. For us it asks the question of who and what we are.

Ethics—the branch of philosophy dealing with values relating to human conduct, with respect to the rightness or wrongness of certain actions and to the goodness or badness of the motives and ends of such actions.

What are the relationships between science and philosophy?

Epistemology → Science
Science is dependent on epistemology to define and understand the epistemic values of science.

Ontology ← Science
Ontology is dependent on science for reliable knowledge of who and what we are.

Ethics ← Ontology ← Science
In turn, ontology informs ethics by establishing our identity which determines what we consider of importance and therefore our values.

Ethics → Science
Ethics defines and informs professional science of the ethical issues and obligations that arise from scientific research.

The Division of Ethics

The primary division of ethics is into:

A) the study of the ethical relationships between moral entities

B) the study of the sources of motivation for ethical behavior

Ethical relationships can be further subdivided into:

1) the ethical relationships within a self identified group

2) the ethical relationships between autonomous groups

3) the ethical relationships between humans and other life-forms

The sources of motivation for ethical behavior fall into only two categories:

1) "ethical" behavior motivated by innate "moral sentiments" or intuition

2) ethical behavior motivated by rational thought

Rational motivations can be further divided into:

a) those guided by absolute categorical imperatives

b) those guided by provisional ultimate goals

Absolute Principles or Outcomes: Traditional Ethical Theories

Moral Legalism: The moral rightness of acts is determined solely by rules, principles, or commandments. Examples of moral legalism are:

1. Ethical egoism: One ought always to maximize one's personal good
2. Divine command theory: Whatever God commands is right.
3. Natural Law Ethics: One ought always to act in accordance with nature.
4. Kantianism: One ought always to act on maxims that can be universal.
5. Utilitarianism: One ought always to maximize the general good.
6. Principle of justice: One ought always to act justly.

Moral Particularism: The rightness of acts depends solely on the situations in which they are performed and is not derived from rules, principles, or commandments. (modified from Holmes 1998)

Consequentialist opposed to Non-Consequentialist Ethics

Moral Legalism can be either consequentialist or non-consequentialist in perspective.

Utilitarianism is based on the legalistic principle that one ought always to maximize the general good. But it is consequentialist in that it is the outcome that counts.

Divine command theory, in contrast, gives absolute moral rules that must be obeyed without regard to consequences.

Moral Particularism is predominately consequentialist but may be guided by moral principles as in utilitarianism. It is important, however, to recognize that, in moral particularism, moral principles are secondary to outcomes. (modified from Holmes 1998)

The Sectarian Flaw of Absolute Moral Rules

All absolute moral rules suffer from a key logical flaw. All of them are defined by a particular sect, usually religious. Therefore, by definition they are sectarian in the sense of rigidly adhering to a particular set of doctrines and intolerant of other views.

"There are many religions in the world, with several of them (including almost all branches of Christianity and of Islam) claiming to be valid for all people at all times. Each has numerous

adherents of the highest integrity and intelligence. These faiths contradict each other, and so at most only one of them can be right. Accordingly a huge number of believers must be wrong."
—Hermann Bondi, 1993

The problem for public ethics in a pluralistic society is which set of sectarian absolute moral rules could we use without alienating the rest of society.

What is ethical behavior? -- A Consequentialist's Definition

Ethical behavior is social behavior that is modified by rational considerations in the present *to achieve shared goals in the future*. Ethical behavior is rational, mutually end-directed social behavior.

Who are the ethical players?

Moral Subjects) Those beings to whom moral agents have moral obligations are moral subjects. For the purpose of this course, all living humans are considered moral subjects. This leaves out, for the moment, whether other life-forms should be considered moral subjects.

Moral Agents) Moral agents are those living beings that, because they have the capacity for rational thought, are independently able to identify and discharge moral obligations to moral subjects. Therefore, until we discover rational life-forms other than human beings, only human beings can be moral agents.

Moral Followers) Moral followers are those human beings that are unable to independently identify moral obligations toward moral subjects, but are able to control their own behavior to the extent they are able to follow moral rules established by moral agents.

"What alone can *our* teaching be? -- That no one *gives* a human being his qualities: not God, not society, not his parents or ancestors, not *he himself*. No one is accountable for existing at all, or for being constituted as he is, or for living in the circumstances and surroundings in which he lives. The fatality of his nature cannot be disentangled from the fatality of all that which has been and will be.". Friedrich Nietzsche (1844 -1900) from *Twilight of the Idols* (1888)

Nietzsche's Dictum

Because no living entity had control over their conception and birth, no living entity is morally responsible for their existence nor for how they are genetically constituted.

Nietzsche's Dictum is the rational explanation why all living humans, as moral subjects, should be treated as equally valuable by moral agents. Aristotle, however, pointed out that, although all moral subjects are equally valuable, they should not be treated equally. They should be treated, rather, according to their needs.

Moral Agents as Rational, Autonomous Thinkers

To be a moral agent you must be aware of the causal relationship between behavior and goals. As moral behavior is purposeful, end-directed behavior, a moral agent must understand the end toward which their behavior is modified to achieve. This awareness is a knowledge based, rational state of consciousness. A new-born child has no knowledge of the world and cannot, therefore, be a moral agent. An individual who is insane is incapable of rational thought and, equally, can not be a moral agent. Both the new-born and the insane are moral subjects by virtue of their being alive, but they are incapable of identifying and discharging moral obligations to other moral subjects. Moral agents must be able to identify those moral subjects toward whom they have obligations and the obligations they have toward them. This requires rational, autonomous thought.

The Limitations of Moral Followers

The last category of moral entity, that of moral followers, represents the juvenile state of moral behavior. It is that category of individuals who are able to control their behavior to the extent that they can follow a proscribed set of rules given to them by moral agents. The crucial difference is that moral followers, as opposed to moral agents, are unable to make moral decisions about novel moral problems not covered by the code of behavior in which they have been indoctrinated. Being a moral agent requires an individual to be rationally self-autonomous. Being a moral follower requires only that individuals be indoctrinated into a moral code of behavior during their primary socialization. Young children go through this process and are expected to be able to control their behavior morally sometime after early childhood. In our society it is accepted that this indoctrination process should be complete by the age of eighteen. However, far too few eighteen-year-olds, as well as adults, have sufficient knowledge of our world and are sufficiently rational, self-autonomous thinkers to be moral agents. Most adults, most of their lives, are able only to be moral followers, and many are incapable of even this.

Public Ethics in a Pluralistic Society

Which system of ethical thought can we use in a pluralistic society?

Mediational Ethics (a.k.a. Provisional or Consensual ethics)

"A mediational normative ethics uses knowledge about the world and man to recommend optimal human behavior for the implementation of assumed ultimate goals." (Campbell 1979)

What ethical principles can we agree to use in a system of moral particularism such as mediational ethics?

Reciprocity -- "...the principle of equal consideration of the interests of all." (Singer 1981)

Ethical cooperation between *rational like-kinds* can be based on the logical assumption that the desires an individual has are the same as others like themselves. Reciprocity subsumes the concepts equity, fairness, and justice.

Reciprocity recognizes that all members of a society should have an equal share in the benefits and obligations of their society. The lesson from history is that when a society marginalizes part of its citizens, it dooms itself to failure. Justice, equity, and fairness are not disembodied concepts. They are the principles, discovered in our dark past through trial and error, that sustain a society through time.

Assumed Ultimate Goals: Biological Continuity, Sustainability, Optimization, and the Quality of Human Life

"For ethics, we have to make an *unproven choice* of values. I suggest *human survival under humane conditions*: We don't want humans under r-selected conditions (as many offspring as possible, most of them dying, earlier and earlier pregnancies, etc.)." (Donald T. Campbell in Callebaut 1993).

The moral prescription of sustainability is derived from the imperative of biological continuity. If we wish to maintain biological continuity, our behaviors must be indefinitely sustainable. But this is not enough. We must define what type of world we wish to sustain.

What must be added to sustainability is the concept of optimization. It is not enough for the human mind to maintain biological continuity without addressing the quality of human life. Ethical behavior is shared, end directed behavior. Thus the end toward which our behavior is directed is defined by what we collectively wish for the future. But defining this desired future must be done as a part of defining ourselves. And the fundamental observation, that is crucial, is that each of us at birth has an inherent constructive potential. Without regard to specific outcomes, it is enough for us to set as our goal that every individual be helped to achieve this potential. Every child born should be given the chance to live an optimal life.

Optimization & Reproduction

Condorcet's Obligation -- "Men will know then that, if they have obligations towards beings who are yet to come into the world, they do not consist in giving to them existence only, but happiness as well." from *Sketch for an Historical Picture of the Progress of the Human Mind* by Antoine-Nicolas de Condorcet (1795)

The ethical concept of optimization is the moral goal, expressed in Condorcet's obligation, of providing the best chance for every child to live an optimal life history. We may fail because of unforeseen events, but we must try to make our world better for future generations.

Unit Four: Genetics and Medicine

Topic One: A Primer on Human Genes

• The human genome is the biological instruction for how an individual is formed and how the cells in the body function.

• There are between 20,000 to 25,000 genes in the human genome.

• Except for identical twins, the gene structure is unique in each individual.

• Half the DNA in the nucleus of each cell in a person come from each parent.

• Genes direct the formation, or expression, of proteins that a cell uses to function, repair or defend itself, and to divide.

• Genes are contained in the chromosomes in the nucleus of each cell.

• There are 22 numbered chromosomes, plus two that determine gender, X and Y. A female has two X chromosomes, while a male has an X and a Y.

• A human normally has 23 pairs of chromosomes (46 total).

• A complete human genome is contained in coiled double helixes of DNA, or deoxyribonucleic acid. Stretched out, the coil would be 5 feet long, but only 20 microns wide.

• About 3 billion DNA subunits, called base pairs, make up the human genome.

• Base pairs are composed of four types of chemicals, called nucleotides, that are weakly bonded in pairs to link the sides of the DNA double helix. The base pairs resemble rungs in a coiled ladder.

• The nucleotides are called adenine, thymine, cytosine and guanine. They are abbreviated A, T, C and G in the scientific description of the genome.

• The bases form specific nucleotide pairings, with "A" linking only with "T", and "C" only with "G".

• Genes can have thousands of base pairs. The sequence and arrangement of these base pairs create a genetic code.

• Genes give coded instructions to the cell on how to assemble proteins. Making of a protein from this code is called “gene expression.”

• Many human disorders are caused by genetic flaws, or by the absence of one or more genes.

• Once a gene has been linked to a human disorder, researchers hope to learn how to manipulate, correct or replace that flawed gene, or the protein its expresses, in order to treat the disorder.

Nucleic Acids and Protein Synthesis

Transcription

DNA (genes) ----> to mRNA ----> to ribosomes

Translation

amino acids ----> to tRNA----> to ribosomes ----> makes proteins

genes code only for proteins and RNAs

Genetics as Information -- Terms and Definitions

genes ----> genetic information

genome ----> genetic makeup of the individual

gene pool ----> genetic makeup of a population

biodiversity ----> genetic sum of all of life on earth

genotype ----> to phenotype

Genetics and Reproduction -- Terms and Definitions

genetic mutations

alleles

variation in genes   variation in alleles

dominant alleles   recessive alleles

heterozygote   homozygote

gene expression

single gene traits   polygenic traits   pleiotropy

somatic cells   germ cells

mitosis   meiosis

Unit Four: Genetics and Medicine

Topic Two: Genetic Screening for Cystic Fibrosis

The first rings in Peter Singer's expanding circle are the ethical issues related to individuals. Nothing is more immediate to the individual than reproduction, and nothing is more devastating to parents than genetic disease in their children.

What scientific knowledge do we need to understand these issues?

What are the ethical issues raised by genetic screening for carriers of genetic diseases?

The Discovery of the Cystic Fibrosis Gene

Francis Collins (1950 -), M.D., Ph.D., is a physician-geneticist and the current Director of the National Human Genome Research Institute. In 1989, together with Lap-Chee Tsui and Jack Riordan of the Hospital for Sick Children in Toronto, Canada, his research team from the University of Michigan identified the gene for cystic fibrosis.

• The cystic fibrosis gene sits on the long arm of chromosome 7. One out of every 29 people in the Caucasian population carry the genetic mutation for CF in this gene. Chromosome 7 has 150,000,000 base pairs of DNA.

• The CF gene region has 230,000 DNA base pairs which spell out a series of 1480 amino acids that curl up to make the Cystic Fibrosis Transmembrane conductance Regulator protein. The little triangle shows the location of the 3-base-pair deletion mutation that was discovered.

• A normal gene makes this protein that regulates the passage of chloride ions and hence the secretion of mucous in epithelial (surface) cells lining the gut, lungs, etc. One missing amino acid at this spot (ΔF508) in the protein causes the CF.

Excerpt from **Cystic Fibrosis**

by Michael J. Welsh and Alan E. Smith, *Scientific American*, December, 1995

Testing Dilemmas

Now that many genetic mutations leading to cystic fibrosis have been pinpointed, prospective parents can easily find out whether they are likely to be carriers of the disease, that is, whether their cells silently harbor a defective copy of the CFTR gene. Couples can also learn whether an already developing fetus has inherited two altered copies of the gene (one from each parent) and ill thus be afflicted with cystic fibrosis.

The difficulty for many people is deciding how to proceed once they receive their test results. The trouble arises in part because the laboratories that perform the genetic analyses do not detect every mutation in the CFTR gene. Consequently, a reassuring negative finding may not fully rule out the possibility that someone is a carrier or is affected with cystic fibrosis. (A favorable prenatal test result will be conclusive, however, if the fetus is shown to lack the specific CFTR mutants known to be carried by the parents.) Moreover, it is not yet possible to predict the extent of symptoms in a person who inherits two CFTR mutants; even if the inherited genes are usually associated with highly severe or less severe disease, such associations do not necessarily hold true in every individual. Prospective parents need to understand, therefore, that a child born with cystic fibrosis today will still have to cope with the disease and may not be spared a premature death.

NIH Consensus Statement on Genetic Testing for Cystic Fibrosis,

16 April 1997

Genetic testing for CF should be offered to adults with a positive family history of CF, to partners of people with CF, to couples currently planning a pregnancy, and to couples seeking prenatal care. The panel does not recommend offering CF genetic testing to the general population or all newborn infants. The panel advocates active research to develop improved treatments for people with CF and continued investigation into the understanding of the pathophysiology of the disease. Comprehensive educational programs targeted to health care professionals and the public should be developed using input from people living with CF and their families and from people from diverse racial and ethnic groups. Additionally, genetic counseling services must be accurate and provide balanced information to afford individuals the opportunity to make autonomous decisions. Every attempt should be made to protect individual rights, genetic and medical privacy rights, and to prevent discrimination and stigmatization. It is essential that the offering of CF carrier testing be phased in over a period of time to ensure that adequate education and appropriate genetic testing and counseling services are available to all persons being tested.

NIH Consensus Statements are prepared by a nonadvocate, non-Federal panel of experts, based on (1) presentations by investigators working in areas relevant to the consensus questions during a 2-day public session; (2) questions and statements from conference attendees during open discussion periods that are part of the public session; and (3) closed deliberations by the panel during the remainder of the second day and morning of the third. This statement is an independent report of the panel and is not a policy statement of the NIH or the Federal Government.

Supplemental Reading Assignment

Excerpt from **Cystic Fibrosis Gene Test Offered**

By Lauran Neergaard AP Medical Writer,
Associated Press, Monday, 1 October 2001

WASHINGTON (AP) - Gene testing is going mainstream: Starting this month, tens of thousands of white Americans will be offered testing to see if they carry a gene mutation that causes cystic fibrosis even if no one in their family has the disease.

Under new guidelines, obstetricians and gynecologists are supposed to offer the gene test to every Caucasian - or the partner of a Caucasian - who is pregnant or considering having a baby.

It marks the first time gene tests are being offered to the general population. Until now, they have been recommended just for small groups of people who know they're at high risk for a particular inherited disease, such as when an illness runs in the family.

Are we ready for mainstream gene tests? The American College of Obstetricians and Gynecologists is betting that with a little education, Americans will be savvy enough medical consumers that the screening will prove a boon.

To help expectant couples decide whether to accept the test, the group has prepared easy-to-understand educational pamphlets - available from your doctor - explaining cystic fibrosis, how gene testing works, and the relevance of parents-to-be discovering they have the gene mutations that cause it.

Babies must inherit a bad gene from both parents to have the disease, so if the mother has a mutation, the dad must be tested, too. "It's something patients have to decide - do they want it or not," stresses Dr. Michael Mennuti of the University of Pennsylvania, who co-authored the testing guidelines.

About 30,000 American children and young adults are living with cystic fibrosis. It attacks their lungs, clogging them with a thick mucus, and can harm digestion and vitamin absorption by clogging the pancreas and intestines. Treatment has improved in recent years, lengthening life span. Still, patients typically die in their 30s, most from lung damage or infection.

Why test so many parents? While it can affect anybody, cystic fibrosis is the most common inherited disease among Caucasians. People can carry the defective gene without knowing it - more than 10 million Americans do, including one in every 29 whites.

But because there are so many unsuspecting carriers, most babies with the disease are born into families that didn't know they were at risk. If both parents harbor the defective gene, they have a one-in-four chance of having a baby with the incurable disease.

"The vast majority of couples will get reassuring news," that they aren't carriers, notes Dr. Francis Collins of the National Institutes of Health, who co-discovered the gene in 1989.

Testing is best done before a woman gets pregnant, he says. If both parents are carriers, they might opt for in vitro fertilization, for instance, where the resulting embryos can be tested for the disease and only healthy ones are implanted into the mother's uterus.

If parents learn they are carriers early in pregnancy, the fetus can be tested. If the fetus does have it, abortion is one option - but many such parents do as patients of Dr. Debra Baseman recently did: They spent the months of pregnancy learning about top-notch care and lining up specialists for their child. Very early care, especially nutritional care, keeps many patients healthier longer.

Parents often say, "the medications are good, the life span is longer, and who knows what medications will be around in 5 or 10 years," said Baseman, a Princeton, N.J., obstetrician who has offered routine screening for cystic fibrosis for several years and says about three-fourths of her patients accept it.

The guidelines say the test should not be restricted to Caucasians. While they are the main target because of their higher risk, the test should be available to anyone who wants it. One in 46 Hispanics carry the bad gene, as do one in 62 blacks and one in 90 Asian Americans.

A test typically costs about $265; doctors say many insurers do pay for it.

The test is good but not 100 percent accurate. There are about 1,000 known mutations in the gene that causes it, and the new guidelines advise test laboratories to check for a minimum of the 25 most common. Genzyme Corp., the largest test provider, typically tests for 87 mutations.

How well this widespread gene testing works will influence how other gene tests are introduced to Americans. “It will be very important to see how this goes,” Collins says. “Certainly it requires the obstetricians to become more familiar with genetics than many of them have previously had occasion to do.”

Gene Test Accuracy by Ethnic Group

Ethnic Group	% accuracy	chance of being a carrier
Ashkenazi Jewish	97%	one in 29
Non-Jewish Caucasians	80%	one in 29
African-Americans	69%	one in 65
Hispanic-Americans	57%	one in 46
Asian-Americans	(no data)	one in 90

What are the ethical issues raised by genetic screening for cystic fibrosis?

“Testing is best done before a woman gets pregnant, he says. If both parents are carriers, they might opt for in vitro fertilization, for instance, where the resulting embryos can be tested for the disease and only healthy one are implanted into the mother’s uterus.”

“If parents learn they are carriers early in pregnancy, the fetus can be tested. If the fetus does have it, abortion is one option -- but many such parents do as patients of Dr. Debra Baseman recently did: They spent the months of pregnancy learning about top-notch care and lining up specialists for their child. Very early care, especially nutritional care, keeps many patients healthier longer.”

“Every attempt should be made to protect individual rights, genetic and medical privacy rights, and to prevent discrimination and stigmatization.”

“The test is good but not 100 percent accurate. There are about 1,000 known mutations in the gene that causes it, and the new guidelines advise test laboratories to check for a minimum of the 25 most common. Genzyme Corp., the largest test provider, typically tests for 87 mutations.”

Some of the Ethical Issues related to Cystic Fibrosis Screening

- The Status of Fertilized Embryos
- Therapeutic abortion
- Discrimination against Carriers
- Stigmatization of Carriers
- The Right to Medical Privacy
- The "Right" to Genetic Health

What is the legal status of embryos fertilized in vitro?

Therapeutic abortion

When, if ever, is therapeutic abortion ethically justified?

When, if ever, is a therapeutic abortion ethically required?

Lawsuits, Smoking, and Fetal Alcohol Syndrome

Are unborn fetuses persons under the law and, therefore, afforded the protection of the courts even against the desires of the mother?

Can a child born with fetal alcohol syndrome receive compensation from the mother (by lawsuit) for the actions of their mother during her pregnancy?

Excerpt from **The Politics of Fetal / Maternal Conflict**

by Ruth Hubbard in *Power and Decision: the Social Control of Reproduction*. Cambridge: Harvard School of Public Health (1994), 311-324.

It is easy to extrapolate from court-mandated caesarians [which have occurred] to court-mandated Prenatal tests and therapies. This has not happened yet, but it may once prenatal testing or therapy becomes standard medical practice. And what if courts one day decide that, if no therapy is available and a fetus is predicted to be disabled, the woman must have an abortion?

This suggestion is not altogether far-fetched. Insurance discrimination against families predicted to have a child with a disability has already occurred. Medical geneticist Paul Billings and his colleagues (1992), in their research into genetic discrimination, have come across an instance that is not very different from this hypothetical scenario. In this case, a woman who had borne one child with cystic fibrosis decided to have her fetus tested for this condition during a subsequent pregnancy. When the result indicated that this baby, too, was going to have cystic fibrosis and the woman decided to continue the pregnancy (which is not unusual for families who have experience caring for a child with cystic fibrosis), the HMO that provided the family's health care announced that it was prepared to pay for an abortion, but not for continued prenatal care or the health care of the future baby because that baby now had what insurers call a pre-existing condition. Only after the family threatened to publicize this decision and, if necessary, take it to court, did the decision get reversed. As prenatal tests proliferate, these kinds of situations are going to become more common, unless we get laws passed to prevent such forms of discrimination and coercion.

Discrimination against Carriers

Is discrimination against carriers of genetic diseases ever justified?

Examples of discrimination could be insurance companies who, based on information that an individual carried the mutation for a genetic disease, deny an individual insurance coverage or dramatically increased the cost of insurance for that individual.

Discrimination could also be an employer who denies an individual a job or a promotion based on that individual being a carrier of a genetic mutation.

Stigmatization of Carriers

Is the stigmatization of carriers of a genetic disease ever justified?

The Right to Medical Privacy

What rights to privacy does a carrier of a genetic disease have in the United States?

Unit Four: Genetics and Medicine

Topic Three: The Human Genome Project: "In short, the international Human Genome Project, which involves hundreds of scientists worldwide, is an investigation of ourselves."

What is the Human Genome Project?

The Human Genome Project (HGP) is an ambitious international research program to understand the hereditary instructions that make each of us unique. The goal of this effort is to determine the complete nucleotide sequence of human DNA, all 3 billion bits of information, and to localize the estimated 20,000-25,000 genes within the human genome by the year 2005.

Even before it is complete, the Human Genome Project promises to transform both biology and medicine. Our genes orchestrate the development of a single-celled egg into a fully formed adult. Genes influence not only what we look like but what diseases we may eventually get. Understanding the complete set of genes, known as the human genome, will shed light on the mysteries of how a baby develops. It also promises to usher in an era of molecular medicine, with precise new approaches to the diagnosis, treatment, and prevention of disease. In short, the international Human Genome Project, which involves hundreds of scientists worldwide, is an investigation of ourselves.

From the inception of the HGP, it was clearly recognized that acquisition and use of such genetic knowledge would have momentous implications for both individuals and society and would pose a number of policy choices for public and professional deliberation. Analysis of the ethical, legal, and social implications of genetic knowledge, and the development of policy options for public consideration are therefore yet another major component of the human genome research effort.

Launched in 1990, the project is supported in the United States by the National Institutes of Health and the Department of Energy.

James D. Watson and The Human Genome Project

The genesis and history of the Human Genome Project has been intertwined to a remarkable degree with the career of one man, Dr. James D. Watson (1928-). Watson is known internationally for his discovery with Dr. Francis Crick (1916-2004) of the structure of DNA in 1953, for which he shared the 1962 Nobel Prize in Physiology and Medicine. He later helped start the human genome project which, less than 50 years later, is coming to fruition. "I would only once have the opportunity to let my scientific career encompass a path from the double helix to the three billion steps of the human genome," Dr. Watson wrote in explaining his decision to become the first director of the human genome project at the National Institutes of Health in 1988. Dr. Watson was director until the early 1990s. The project, headed now by Dr. Francis Collins, is ahead of schedule, and accelerating.

What has the Human Genome Project cost?

The Human Genome Project is sometimes reported to have a cost of three billion dollars. However, this figure refers to the total projected funding over a 15 year period (1990-2005) for a wide range of scientific activities related to genomics. These include studies of human diseases, experimental organisms (such as bacteria, yeast, worms, flies, and mice); development of new technologies for biological and medical research; computational methods to analyze genomes; and ethical, legal, and social issues related to genetics. Human genome sequencing represents only a small fraction of the overall 15 year budget.

What have we learned about ourselves from molecular genetics?

The Research

• Mitochondrial DNA Studies

These were the first gene sequence studies of human genetics and were only possible because of the small number of genes on the loop of DNA found in each mitochondria. Because mitochondria are only passed from the mother in the egg cell, mtDNA is only passed through the female lineage. The entire DNA sequence of the human mitochondrial (mt) genome - 16,569 nucleotides was determined in 1981, well in advance of the Human Genome Project. The mt genome contains 37 genes, all of which are involved in the production of energy and its storage in ATP.

• Nuclear DNA Studies

It is more difficult to study the genetic material found in the nucleus of cells because of the greater number of genes. However, the Human Genome Project now holds the promise doing detailed studies of the genetic variation in our nuclear DNA.

• Y- Chromosome Studies

Genetic studies of the Y- chromosome are a form of nuclear DNA studies where, uniquely, genes are past only from fathers to sons.

The Findings

•"Recent research based on the full sequence of mtDNA reduced the estimate for the origin of modern humans to slightly less than 150,000 years ago." (Cavalli-Sforza 1998)

• "Population genetic studies are in approximate agreement with archaeological observations indicating that anatomically modern humans (i.e. similar, as far as bone morphology goes, to living humans) are found in the past 100,000 years exclusively in Africa, or very close to it (the Middle East) and spread from it to the other continents." (Cavalli-Sforza 1998)

• “The number of our ancestors just before the expansion (“origin”) of modern humans was small. Many genetic systems provide reassuringly congruent estimates: all indicate that the approximate population size was on the order of 10,000 breeding individuals [this is 20,000 individuals total].” “Although the size of this population must have fluctuated over time, it was often reduced to the level of several thousands of adults.” (Harpending 1998)

• “A current estimate [for the genetic separation of Africans and non-Africans] gives a value closer to 60,000 y.a. with a standard error of close to 20% [72,000 y.a. to 48,000 y.a.].” (Cavalli-Sforza 1998)

Out of Africa

“In a report on the "African Origin of Modern Humans in East Asia." A team of geneticists took samples from 12,127 men from 163 Asian and Oceanic populations, tracking three genetic markers on the Y chromosome. They discovered that every one of their subjects carried a mutation at one of those three sites that can be traced back to a single African population some 35,000 to 89,000 years ago. Their paper marks a major victory for the "Out of Africa" hypothesis that all modern people can trace their heritage to Africa. It is also a significant blow to the "Multiregional" hypothesis that modern human populations have multiple origins dating back many hundreds of thousands of years.

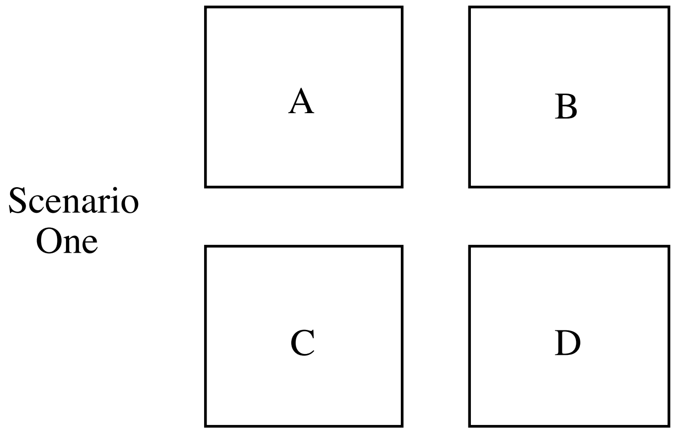
One of the chief defenders of Multiregionalism, anthropologist Vincent M. Sarich of the University of California at Berkeley, is well known for his vigorous and energetic defense of his beliefs and theories. Yet when this self-proclaimed "dedicated Multiregionalist" saw the new data, he confessed in *Science*: "I have undergone a conversion--a sort of epiphany. There are no old Y chromosome lineages [in living humans]. There are no old mtDNA lineages. Period. It was a total replacement” (Shermer, Scientific American October 2001)

The Case of Humanity’s Missing Mutations

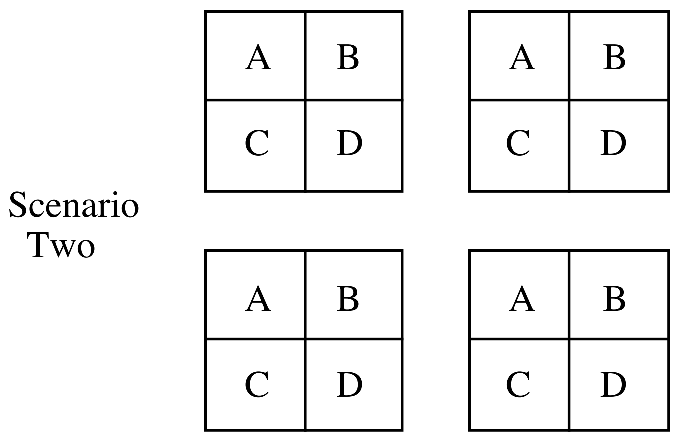
Humanity today numbers over 6 billion, but how closely are these 6 billion individuals genetically related to each other? The answer is “too closely” -- we are missing the number of mutations, and therefore the genetic variation, expected in organisms similar to us, such as chimpanzees and gorillas. “Population geneticist (Jan) Klein thinks that the explosive population growth that occurred in the past 10,000 years may be the cause. According to computer simulations of population growth, the widespread reproduction that accompanies rapid growth mixes genes up throughout a population to a greater degree than in a small population that isn’t reproducing as frequently. The result is an overall genetic sameness.” (Gibbon 1995)

This is reinforced by studies of genetic variation between human populations. “It has been known for some time that human genetic variation is largely between individuals within populations, rather than between populations or even continents.” Recent genetic studies have confirmed this, giving very nearly the same apportionment of genetic variation as classical markers -- 88 to 90% among individuals within populations and 10 to 12% among populations.”

Genetic Variation Between Populations
versus Variation Within a Population



allelic variation is 0% within and a 100% between populations.



allelic variation is a 100% within and 0% between populations.

Excerpt from **What We all Spoke When the World Was Young**

by Nicholas Wade (2000)

"In the beginning, there was one people, perhaps no more than 2,000 strong, who had acquired an amazing gift, the faculty for complex language. Favored by the blessings of speech, their numbers grew, and from their cradle in the northeast of Africa, they spread far and wide throughout the continent.

One small band, expert in the making of boats, sailed to Asia, where some of their descendants turned westward, ousting the Neanderthal people of Europe and others east toward Siberia and the Americas.

These epic explorations began some 60,000 years ago and by the time the whole world was occupied, the one people had become many. Differing in creed, culture and even appearance, because their hair and skin had adapted to the world's many climates in which they now lived, they no longer recognized one another as the children of one family. Speaking 5,000 languages, they had long forgotten the ancient mother tongue that had both united and yet dispersed this little band of cousins to the four corners of the earth.

So might read one possible account of human origins as implied by the new evidence from population genetics and archaeology."

Excerpt from **Teaching Human Evolution**

by David L. Alles and Joan C. Stevenson (2001)

"At some point between 200,000 and 100,000 years ago a population of early humans in Africa crossed the morphological threshold to fully modern humans. The timing of this watershed event is supported by a variety of genetic studies (Cavalli-Sforza 1998). These same studies estimate the number of individuals in this population to be from 20,000 to as few as 2,000 individuals (Harpending 1998). A population of two thousand individuals is about the size of a large high school in America today.

It challenges the imagination to understand that those two thousand individuals are the ancestors to all six billion plus living human beings. What a stunning moment in time to think of those two thousand individuals poised on the brink of a brave new world. In looking back to this moment we can only wonder what our small band of ancestors might think of our world today."

Unit Five: Human Reproduction

Human reproduction is one of many areas in our lives where changes in the degree of control we have are happening faster than our ability to understand their ethical implications.

Topics related to Human Reproduction include:

- Prenatal Care, Testing and Screening
- Conception Control, Birth Control, Population Control
- Assisted Reproductive Technologies (ARTs)
- Gender Selection
- Stem Cell Research
- Cloning Humans
- Genetic Engineering of the Human Germline

What scientific knowledge do we need to understand these topics?

What are the ethical issues raised by these topics?

Topic One: Embryogenesis and Development

The Process of early Human Embryogenesis

The oocyte or unfertilized egg

The egg sits in the middle of a mass of follicular cells that act to protect the egg itself as it moves down the fallopian tube. To reach the egg, sperm must first penetrate this mass (called the cumulus) and then they must bore through the rubbery coat that directly surrounds the egg.

The fertilized egg (also called a zygote or 1-cell embryo)

The cumulus mass is removed manually by movement down the fallopian tube. The egg is the larger of the two balls contained within the thick circular rubbery coat called a zona pellucida. Within the egg, are two smaller concave-looking spherical objects -- each of these is a 'pro-nucleus' contributed by one parent or the other and containing the parental DNA.

The 2-cell embryo.

The first cell division takes place a day after fertilization. (At this stage, it is no longer appropriate to call it a zygote or egg.) From the 1-cell stage of embryogenesis all the way down to the blastocyst stage, the embryo is floating freely without a source of nutrients and it is physically constrained within the zona pellucida. So during this entire period, the embryo remains the same size.

The 4-cell embryo

Once again, each of the cells in the embryo divides. At this stage, it is still possible for each individual cell to become an entire human being. If the embryo breaks apart into its four cells at this stage, four identical quadruplets could develop to birth. Although a rare event, there are many known cases.

The 8-cell embryo

Differentiation has still not taken place. Each cell could become an entire human being (in theory). Therefore, any cell can be removed at this point for genetic diagnosis without any effect on the development of the remaining embryo.

The blastocyst

After approximately four days the embryo now has about 64 cells. The cells are no longer equivalent. The embryo now has a fluid-filled cavity and a portion of the embryo called the Inner Cell Mass lies on the side of the cavity. The half-dozen cells of the ICM are the only ones that will be used to develop the fetus and child. The remaining cells help to form the placenta.

Implantation

Implantation of the embryo into the uterine wall occurs 7-10 days after fertilization. Within implantation, the embryo connects to the maternal blood supply and is now able to grow. At implantation, the woman's body becomes pregnant for the first time. Prior to implantation, the body is unable to detect the difference between an unfertilized egg (on its way out) or a developing embryo.

Topic Two: Prenatal Care, Testing and Screening

Who receives Prenatal Care in the U.S.? (figures are for 1998)

Mothers Receiving 1st Trimester Care: 82.8% (of live births)

Mothers Receiving only Late Care: 3.9%

Teen Mothers Ages 15-19 Receiving 1st Trimester Care: 63.2%

Teen Mothers Receiving only Late Care: 8.8%

Median Number of Care Visits reported: 12.6

(Source: National Vital Statistics Report, Vol. 48, No. 3)

What are the ethical issues that surround prenatal care?

• Unequal access to prenatal care in the U.S.

• Cost effective aid to underdeveloped countries

Topic Three: Conception Control, Birth Control, and Population Control

Conception Control -- The artificial prevention of fertilization

What are the ethical issues surrounding contraceptives?

• When does life begin?

• What is the nature of "personhood?"

Birth Control -- The artificial prevention of birth

Population Control -- The artificial regulation of the size of the human population

The take-home message -- Population control is not the same as conception or birth control.

Unit Five: Human Reproduction

Topic Four: Assisted Reproductive Technologies (ART)

Supplemental Reading Assignment

Excerpts from **Sex in an Age of Mechanical Reproduction**

by Carl Djerassi, *Science*, 285(2 July 1999), 53-54

"In the first half of the 20th century, the onset of menopause was welcomed by many women as a release from continuous pregnancies caused by unprotected and frequently unwanted intercourse. But the arrival of the Pill and other effective contraceptives, together with many more women delaying childbirth until their late 30s or early 40s, raises the concern that menopause may prevent women from becoming mothers at all. Whereas technology's gift to women (and men) during the latter half of the 20th century was contraception, the first 50 years of the new millennium may well be considered the decades of conception. With continuous improvements in assisted reproductive technologies (ART), we are seeing a gradual separation of sex and fertilization, with sex taking place "in bed" and fertilization under the microscope. This separation is shifting the balance of reproductive power into the domain of women.

The first successful ART was the in vitro fertilization (IVF) technique developed by Steptoe and Edwards in the United Kingdom in 1977. They removed a woman's egg and exposed it to millions of her husband's sperm under the microscope. Two days later the fertilized egg was transferred back into the woman's uterus, resulting in the birth, 9 months later, of a healthy baby girl, Louise Joy Brown. Since then, more than 300,000 babies have been born to women who, without IVF technology, would be infertile, a technological feat now taken for granted in the affluent countries of the world.

Although still largely unrecognized, the development of intracytoplasmic sperm injection (ICSI) by van Steirteghem, Devroey and colleagues in Belgium in 1992, was an even greater technological achievement. These investigators successfully fertilized a human egg by direct injection of a single sperm under the microscope, followed by reinsertion of the egg into the woman's uterus. Given that the fertilization of a woman's egg during normal intercourse requires tens of millions of sperm, and that a man ejaculating even as many as 3 million sperm is still functionally infertile, ICSI is a powerful tool for the treatment of male infertility. More than 10,000 ICSI babies have been born since 1992."

"ICSI raises many ethical and social issues. For example, once the effective separation of Y and X chromosome bearing sperm has been perfected, ICSI will enable sex predetermination of the offspring with a high degree of success. For a couple with three or four daughters who would like a son, such sex predetermination may be of benefit to society, whereas it would be disastrous if practiced widely in societies that greatly favor male children over girls. Consider the capability of preserving the sperm of a recently deceased man in order to produce (through ICSI) a child months or perhaps even years later. Using the frozen sperm and egg of deceased parents would generate instant orphans under the microscope, a scenario with serious implications for society. But it does not take much imagination or compassion to conceive of circumstances where the surviving wife might use the sperm of a beloved deceased husband so that she can have their only child." "These are intrinsically gray areas, and decisions about the applications of ICSI and other ART cannot be provided by scientists or technologists. The ultimate judgment must be that of society--hopefully well-informed--which, in the case of sex and reproduction, really means the affected individuals.

Although these scenarios will be considered by many as "unnatural", the successful doubling of the average life expectancy during this century in many parts of the world, which now ensures that women live longer than men (at least in affluent societies), can be considered just as "unnatural". Now that people are living longer but healthier lives, a woman who becomes a mother at 45 could raise a child for much longer than was true for many 20-year-old mothers at the beginning of this century. Of course, motherhood at an older age is physically, psychologically, and economically suitable only for certain women, but at least the choice is now available in wealthy countries. The increased availability of ART is a characteristic of affluent, geriatric societies (such as those of Western Europe and Japan, where more than 20% of the population are over 60). But even within these countries, the cost of such reproductive technologies (frequently not covered by insurance) is such that only the more affluent citizens can afford them. Three-quarters of the world's population is represented by the pediatric countries of Africa, Asia, and much of Latin America, where more than 40% of the population may be below 15 years of age and where contraception rather than conception will be the catchword for decades to come.

"' The technique of reproduction detaches the reproduced object from the domain of tradition,' wrote Walter Benjamin in his 1936 essay, *The Work of Art in an Age of Mechanical*

Reproduction. By replacing "the work of art" by "sex" and substituting "offspring" for "reproduced object," it becomes clear that Benjamin's ideas could equally well apply to assisted reproduction. Detaching the child from traditional procreation may well be the most fundamental ethical issue raised by ART. Neither science nor the humanities have so far adequately prepared us for the consequences of sex in an age of mechanical reproduction,"

Carl Djerassi (1923 -) is a professor of chemistry at Stanford University. In 1951 he and his team synthesized the first steroid oral contraceptive, norethindrone, which is still today one of the active ingredients of the oral contraceptive that is taken by millions of women.

Terms and Definitions

Assisted Reproductive Technology (ART) - Fertility treatments that involve a laboratory handling eggs or embryos, such as in vitro fertilization.

In vitro - Done outside the body.

In vivo - Done within the living body.

Super-Ovulation -- During a natural menstrual cycle, usually, only one follicle develops to maturity, although many may started in the initial 'cohort' of primordial follicles destined for that cycle. Superovulation with hormones can result in many follicles developing to maturity producing an average of 8-12 eggs -- sometimes many more -- that can then be harvested in vivo for artificial fertilization.

Egg retrieval -- The egg is removed from the ovary by one of two methods. One uses an ultrasound probe and a suction device inserted through the vagina. The other, laparoscopy, uses a thin, optical tube inserted through an incision near the navel. The egg is removed by suction.

ART Techniques

In Vitro Fertilization (IVF) developed in 1977
Used to treat female infertility
300,000 babies since 1977

Intracytoplasmic Sperm Injection (ICSI) developed in 1992
Used to treat male infertility
10,000 babies since 1992

What are the ethical issues raised by assisted reproductive technologies?

- Post-Menopause Reproduction
- Unequal Access to Technologies
- The separation of traditional procreation from reproduction
- Gender (Sex) Selection

Post-Menopause Reproduction

"In the first half of the 20th century, the onset of menopause was welcomed by many women as a release from continuous pregnancies caused by unprotected and frequently unwanted intercourse. But the arrival of the Pill and other effective contraceptives, together with many more women delaying childbirth until their late 30s or early 40s, raises the concern that menopause may prevent women from becoming mothers at all. Whereas technology's gift to women (and men) during the latter half of the 20th century was contraception, the first 50 years of the new millennium may well be considered the decades of conception."

"Now that people are living longer and healthier lives, a woman who becomes a mother at 45 could raise a child for much longer than was true for many 20-year-old mothers at the beginning of this century. Of course, motherhood at an older age is physically, psychologically, and economically suitable only for certain women, but at least the choice is now available in wealthy countries."

A second issue involves the use of donated eggs and the use of in vitro fertilization to allow women who have gone through menopause to become pregnant and have children at even older ages beyond the mid-forties.

What are the ethical issues raised by post-menopause reproduction?

- Women, Education, and Professional Careers
- Child Rearing by older Parents

Unequal Access to Technologies

"The increased availability of ART is a characteristic of affluent, geriatric societies (such as those of Western Europe and Japan, where more than 20% of the population are over 60). But even within these countries, the cost of such reproductive technologies (frequently not covered by insurance) is such that only the more affluent citizens can afford them."

"Three-quarters of the world's population is represented by the pediatric countries of Africa, Asia, and much of Latin America, where more than 40% of the population may be below 15 years of age and where contraception rather than conception will be the catchword for decades to come."

What ethical issues arise because of the unequal access to assisted reproductive technologies?

- Will the unequal access to reproductive technologies increase existing economic inequality in the U.S.?
- What are the reproductive needs of underdeveloped countries?

Unit Five: Human Reproduction

Topic Five: Gender Selection -- The artificial selection of the sex of an unborn child

Supplemental Reading Assignment

Excerpt from **Fertility Ethics Authority Approves Sex Selection**

By Gina Kolata, NYT, National Report, A14, 28 September 2001

In a letter that has stunned many leading fertility specialists, the acting head of their professional society's ethics committee says it is sometimes acceptable for couples to choose the sex of their children by selecting either male or female embryos and discarding the rest.

The group, the American Society for Reproductive Medicine, establishes positions on ethical issues, and most clinics say they abide by them. One fertility specialist, Dr. Norbert Gleicher, whose group has nine centers and who had asked for the opinion, was quick to act it. "We will offer it immediately," Dr. Gleicher said of the sex-selection method. "Frankly, we have a list of patients who asked for it." Couples would have to undergo in vitro fertilization, and then their embryos would be examined in the first few days when they consisted of just eight cells. Dr. Gleicher is chairman of the board of the Center for Human Reproduction, which has five fertility centers in the Chicago area and four others in Manhattan and Brooklyn.

The acting chairman of the ethics committee at the reproductive medicine society, John Robertson, an ethicist and lawyer at the University of Texas, said he was responding to a request by Dr. Gleicher for clarification of the society's position. Mr. Robertson said that he wrote the letter after consulting with another committee member and that he thought it reflected the group's position.

The committee would have discussed the question at its meeting this month, he said, but the meeting was canceled because of the terrorist attacks. Mr. Robertson added that he expected the committee to discuss the letter at its next meeting, in January.

Mr. Robertson used the term "gender variety" to explain the acceptable uses of the sex selection technique. By that, he said, he meant that a couple who already had a child of one sex could ethically select embryos that would guarantee them that the embryo selected was of the opposite sex. Mr. Robertson wrote that embryo sex selection could be offered for gender variety "when there is a good reason to think that the couple is fully informed of the risks of the procedure and are counseled about having unrealistic expectations about the behavior of children of the preferred gender."

The group's previous statement, in 1999, said that selecting embryos solely to have a child of a particular sex "should be discouraged." Leading fertility specialists said they were taken aback by the new letter and could hardly believe its message.

"Sex selection is sex discrimination, and I don't think that is ethical," said Dr. James Grifo, the president-elect of the Society for Assisted Reproductive Technology, an affiliate of the reproductive medicine society. "It's not ethical to take someone off the street and help them have a boy or a girl." Dr. Grifo, a reproductive endocrinologist at New York University Medical Center, added that publicity over centers offering such sex selection would sully the field and could ultimately make it impossible to help patients with a medical need for the technology.

"What's the next step?" asked Dr. William Schoolcraft of the Colorado Center for Reproductive Medicine in Englewood. "As we learn more about genetics, do we reject kids who do not have superior intelligence or who don't have the right color hair or eyes?"

The embryo selection method, called preimplantation genetic diagnosis, has been available for about a decade, but was reserved almost exclusively for couples at risk for having babies with certain genetic diseases. Doctors can test their embryos to see if they have the disease gene before implanting the embryos in the woman's uterus.

But it has always been clear that the method could easily be used for sex selection. It is simple to see if the embryo is male, with an X and a Y chromosome, or female, with two X chromosomes.

Fertility specialists say patients often ask if they can use preimplantation analysis solely to select the sex of their embryos. But most doctors say they refused. "I could have financed my research from now until the day I die if I honored all the requests," Dr. Grifo said. "But this is not the way we want this to go. We want to protect this technique for our genetic patients."

Dr. Gleicher said he felt otherwise. He said he was prompted to ask about using preimplantation genetic diagnosis for sex selection when the reproductive medicine society issued a statement in May that it was ethical to use a different method — sperm sorting — for that purpose.

One center, the Genetics and IVF Institute in Fairfax, Va., is using a sperm-sorting technique that allows it to pick out the vast majority of male sperm. The reproductive medicine society said that if a couple already had one child and wanted to use the method to select the sex of subsequent children, that was ethically permissible.

But, Dr. Gleicher said, if sperm sorting is all right for sex selection, why prohibit preimplantation diagnosis for sex selection? "How can you say that a method that would be 100 percent reliable is not ethically acceptable?" he asked. He brought the question to his own ethics board.

"Our I.R.B. felt that it was unethical to offer an inferior method if a superior method is available," Dr Gleicher said, referring to the institutional review board, an ethics committee.

But Dr. Schoolcraft said he saw a real difference between the two methods. "With sperm sorting, you are not throwing away potential babies," he said.

Like Dr. Grifo, he worried about the future of his field. "We have a responsibility to be conservative and cautious," Dr. Schoolcraft said. "It's our responsibility not to misuse these technologies."

What are the ethical issues raised by gender selection?

Sex selection as sex discrimination

Unit Five: Human Reproduction

Topic Six: Stem Cell Research

The issue of stem cell research burst on the scientific scene in November of 1998 when researchers first reported the isolation of human embryonic stem (ES) cells. The discovery, made by Dr. James A. Thomson, a biologist at the University of Wisconsin, Madison, offers great promise for new ways of treating disease. ES cells, which are derived from four-day-old embryos, can theoretically differentiate into virtually any type of human cell, from blood cells to skin cells. Scientists hope to find ways of using these cells to repair damaged tissue.

What is a stem cell?

Stem cells have the ability to divide for indefinite periods in culture and to give rise to specialized cells. They are best described in the context of normal human development. Human development begins when a sperm fertilizes an egg and creates a single cell that has the potential to form an entire organism. This fertilized egg is totipotent, meaning that its potential is total. In the first hours after fertilization, this cell divides into identical totipotent cells. This means that either one of these cells, if placed into a woman's uterus, has the potential to develop into a fetus. In fact, identical twins develop when two totipotent cells separate and develop into two individual, genetically identical human beings. Approximately four days after fertilization and after several cycles of cell division, these totipotent cells begin to specialize, forming a hollow sphere of cells, called a blastocyst. The blastocyst has an outer layer of cells and inside the hollow sphere, there is a cluster of cells called the inner cell mass.

The outer layer of cells will go on to form the placenta and other supporting tissues needed for fetal development in the uterus. The inner cell mass cells will go on to form virtually all of the tissues of the human body. Although the inner cell mass cells can form virtually every type of cell found in the human body, they cannot form an organism because they are unable to give rise to the placenta and supporting tissues necessary for development in the human uterus. These inner cell mass cells are pluripotent — they can give rise to many types of cells but not all types of cells necessary for fetal development. Because their potential is not total, they are not totipotent and they are not embryos. In fact, if an inner cell mass cell were placed into a woman's uterus, it would not develop into a fetus.

The pluripotent stem cells undergo further specialization into stem cells that are committed to give rise to cells that have a particular function. Examples of this include blood stem cells which give rise to red blood cells, white blood cells and platelets; and skin stem cells that give rise to the various types of skin cells. These more specialized stem cells are called multipotent.

While stem cells are extraordinarily important in early human development, multipotent stem cells are also found in children and adults. For example, consider one of the best understood stem cells, the blood stem cell. Blood stem cells reside in the bone marrow of every child and adult, and in fact, they can be found in very small numbers circulating in the blood stream. Blood stem cells perform the critical role of continually replenishing our supply of blood cells — red blood cells, white blood cells, and platelets — throughout life. A person cannot survive without blood stem cells.

Terms and Definitions

Stem cells - cells that have the ability to divide for indefinite periods in culture and to give rise to specialized cells.

Totipotent - having unlimited capability. Totipotent cells have the capacity to specialize into extraembryonic membranes and tissues, the embryo, and all postembryonic tissues and organs.

Differentiation - The process by which early unspecified cells acquire the features of specific cells such as heart tissue, liver or muscle.

Pluripotent - capable of giving rise to most tissues of an organism.

Multipotant - more specialized stem cells. Examples of this include blood stem cells which give rise to red blood cells, white blood cells and platelets; and skin stem cells that give rise to the various types of skin cells.

What are the ethical implications and issues surrounding stem cell research?

Ethical Disputes

• Opponents of ES cell research hold that human life begins as soon as an egg is fertilized, and they consider a human embryo to be a human being. They therefore consider any research that necessitates the destruction of a human embryo to be morally abhorrent.

• Proponents of ES cell research, meanwhile, point out that in the natural reproductive process, human eggs are often fertilized but fail to implant in the uterus. A fertilized egg, they argue, while it may have the potential for human life, cannot be considered equivalent to a human being until it has at least been successfully implanted in a woman's uterus.

• *In vitro* fertilization clinics routinely create more human embryos than are needed over the course of a fertility treatment, and are therefore left with excess embryos which are often simply discarded. Proponents of research hold that it is morally permissible to use such embryos for potentially life-saving biomedical research. Opponents object to this argument, however, saying that such research would still condone the destruction of embryos.

• Some opponents of ES cell research also argue that research on stem cells obtained from adults is just as promising and renders ES cell research unnecessary. Most scientists, however, dispute this claim, citing great potential in the field of adult stem cells but several drawbacks as compared with ES cells. Proponents of ES cell research advocate funding for both fields.

Unit Five: Human Reproduction

Topic Seven: Cloning -- Artificially producing genetically identical organisms

Dolly was first presented to the public February 24, 1997. Dolly was the first animal ever cloned from genetic material of adult cells.

Supplemental Reading Assignment

Excerpt from **To Clone a Sheep**

Editorial: The Washington Post, A18, Wednesday, 26 February 1997

IF AN EARLY consensus can be said to have emerged in the reactions to Dolly the cloned sheep, it's that Dolly's existence and the success of the technique that made her are signals of some profound alteration in the human condition. This may of course be so, and, whether it is or not, a certain amount of awe is in order at the breaking of so long-standing and symbolic a scientific barrier as the replication of genetic identity. But it's far from obvious that the loss of that barrier must inevitably take us to a place where the issues are unreachable by the tools of morality and common sense. And this will be true even if researchers quickly solve the large number of unanswered technical questions that separate Dolly's cloning from the feared science-fiction scenarios of human mass production, slave factories and carbon-copied armies.

The most common fears in this regard are that people would clone themselves or others in multiple for ghastly purposes such as organ replenishment and that people would clone themselves directly rather than have children out of a desire for immortality or a pure access of ego. But it's not clear why cloned people, however they were grown and even though they were genetically identical to previously existing people, would be (or be seen as) any less "real people" than the second of a pair of identical twins. The cool-headed scientific cautions being heard post-Dolly about the limits of this strictly genetic understanding of identity -- can a person be considered still alive just because his identical twin outlives him, and is there any reason to think clones would resemble one another any more perfectly than identical twins? -- ought to take the edge off this second set of fantasies, although we suppose that the people likeliest to succumb to the temptation are just the people one least wants to have around in perpetuity. As for the ethics of growing a replica of oneself for organ transplant, or six replicas to use as slaves, why would these actions be any less repellent if performed on identically cloned offspring than they would be if done on offspring -- identical or otherwise -- manufactured by their parents in the traditional manner?

Some of these issues have already been sneaking up on society in the form of debates over surrogate motherhood and infertility research. President Clinton Monday instructed a panel to reopen the question of whether the government should fund, and thereby impose some regulation on, the forms of human embryo research that were earlier banned from such funding.

These issues, though, should not be confused with the specific concern that led to the earlier funding ban -- namely, that human embryos were being created in laboratories for the express purpose of being experimented on and destroyed in the process. The process involved in the sheep-cloning by definition involved no new embryos -- that is, newly fertilized eggs constituting brand-new individuals -- but "only" doctored elements from the cell material of two different female sheep and the surrogate womb of a third. Technically, scientifically, this feat is amazing enough. It's important that we not allow the amazement and the novelty to obscure those ethical landmarks that we already have.

Terms and Definitions

Clone - An organism having the same nuclear genes as another organism.

Cloning - The creation of an animal or person that derives its genes from a single other individual.

Somatic cell nuclear transfer - the transfer of a cell nucleus from a somatic cell into an egg from which the nucleus has been removed.

Cloning Humans

DNA is removed from a mammalian egg using suction through a pipette. The empty egg could then have the DNA from (name your favorite celebrity) inserted into it to form a cloned embryo. The embryo would then need implanted into a woman's womb for gestation. It took about 270 miscarriages and stillbirths to clone Dolly, but a recent study by researchers at the Duke University Medical Center found that cloning humans might be safer in some ways.

Unit Six: Human Longevity

How long should we live?

Jeanne Louise Calment was born in Arles, France on February 21, 1875. On Monday August 4, 1997: Jeanne Calment, the world's oldest person, died at age of 122. Her genes may have contributed to her longevity as her father lived to the age of 94 and her mother to the age of 86. Although, she long claimed an occasional glass of Port wine -- along with a diet rich in olive oil -- were the keys to her long life. Quotes attributed to Jeanne Calment: “I've only got one wrinkle and I'm sitting on it.” “I took pleasure when I could. I acted clearly and morally and without regret. I'm very lucky.”

The Top Record Holders

	Years	Days	Born; Died
1. Jeanne Calment	122	164	February 21,1875; August 4,1997
2. Shigechiyo Izumi	120	237	June 29,1865; February 21,1986
3. Sarah Knauss	119	97	September 24,1880; December 30,1999
4. Marie Meilleur	117	230	August 29,1880; April 16,1998
5. Estella Jones	117	229	November 10,1881; June 27,1999
6. Tane Ikai	116	175	January 18,1879; July 12,1995
7. Carrie C. White	116	88	November 18,1874; February 14,1991
8. Janina Izykowska	116	+	February 27,1882 alive Feb 1998

Currently, the oldest living human, Maud Farris Luse, is 114 years old (as of 7/17/2001).

Other Records of Note

Marie-Louise Meilleur 117 years 230 days born August 29,1880; died April 16,1998

Ontario, Canada: Meilleur was born in Kamouraska on Aug. 29, 1880. After her first husband, Etienne Leclerc, died of pneumonia, Meilleur moved to Rapides des Joachims with her four young children to be closer to her sister. In Rapides des Joachims, Meilleur met and later married Hector Meilleur. They had six children together. In 1972, Marie-Louise moved to be with her daughter. At the age of 107, she moved to a nursing home. **At the time of her death, she had 75 grandchildren, 80 great grandchildren and 55 great-great-grandchildren.** She was described as a hard working woman who was strict.

Terms and Definitions

Life Span -- Individuals have a specified life span that is operationally defined by age at death.

Maximum Life Span -- The documented longest-lived member of a species defines the maximum life span.

Life Expectancy -- Life expectancy is the average age to which people are expected to live when they are born. For populations, demographers and actuaries calculate an average life expectancy based on the use of a life table. In heterogeneous populations, like humans, the maximum life-span is always greater than the life expectancy, by definition.

Health Expectancy -- the average age up to which an individual can expect to have vigorous heath. Vigorous health can be defined as being able to move about normally and having clear mental faculties.

Supplemental Reading Assignment

Excerpt from **U.S. Life Expectancy Reaches New High**

By Maggie Fox, Reuters News Service, Oct 10, 2001

Heart disease and cancer are still the biggest killers, but Americans are surviving longer and more are dying of diseases associated with old age, a government report issued on Wednesday showed.

Life expectancy for Americans has reached a new high of 76.9 years, compared with 76.7 years in 1999, mostly because fewer people are dying early from heart disease and cancer, the national Centers for Disease Control and Prevention reported.

Death rates from murder, suicide, accidents, stroke, diabetes, chronic lower respiratory diseases, chronic liver disease and AIDS were also down in 2000, the report said.

More and more Americans are lucky enough to die of old age, said Ari Minino, a demographer at the CDC's National Center for Health Statistics, who helped write the report. "What we are seeing is an emergence and increase in illnesses that affect mostly the older population," Minino said in a telephone interview. "It's just because the population in the United States is getting older."

The report, based on medical files of most of the reported deaths in the United States, finds increases in deaths from Alzheimer's disease, influenza and pneumonia, kidney disease, high blood pressure, and septicemia or blood infection. "These are age-related diseases," Minino said. "There has been an increase in a condition that debuted into our 15 leading causes of death list. It is called pneumonitis," he added. "It afflicts mostly the elderly. It is an injury to the lungs caused sometimes by vomit and sometimes by particles of food or liquid that are aspirated into the lungs."

The report finds that 2,404,598 people died in the United States in 2000, 13,199 more than the year before. But because there were more Americans living overall, the death rate fell. Out of every 100,000 Americans living in 2000, 873 died, down from 877 per 100,000 in 1999. The age-adjusted death rate was even lower, at 872.4. "If we want to compare death rates in, for instance, Florida, with death rates across country, because there are more old people in Florida, the comparison is not fair. Age-adjusted death rate removes that distorting effect so that we can make fairer comparisons," Minino said.

Another piece of good news in the report -- fewer babies died. "The preliminary infant mortality rate in the U.S. fell to its lowest level ever in 2000 -- 6.9 infant deaths per 1,000 live births, down from a rate of 7.1 in 1999," the CDC said in a statement. "A healthy pregnancy is a major factor in reducing the risk of infant death," CDC director Dr. Jeffrey Koplan said in the statement. "Timely prenatal care and avoiding harmful behavior like smoking are two examples of how pregnant mothers can protect the health of their infants."

Men are still more likely to die before women, with the life expectancy for a male born in 2000 now being 74.1 and for a female 79.5 years.

Heart disease and cancer are still the biggest killers of Americans. Heart disease killed more than 700,000 Americans last year and cancer killed more than 550,000.

Among the other top 10 causes of death:

Stroke, which killed 166,000

Chronic lower respiratory diseases, which killed 123,000

Accidents, which killed nearly 94,000

Diabetes, which killed nearly 69,000

Influenza and pneumonia, which killed 67,000

Alzheimer's, which killed more than 49,000

Nephritis and other kidney conditions killed 37,000

Septicemia killed more than 31,000

What is the future maximum human life span? -- Four Opinions

One: March 9, 1999 -- At a recent meeting in Los Angeles, a small group of eminent academic scientists agreed that science might be on the brink of being able to stretch the human life span, perhaps significantly. Future generations, they said, may be able to avail themselves of scientifically established techniques to stretch the human life span like a piece of taffy until it reaches 150, even 200 years.

> “It is going to be very hard for us to deal with. The idea of expanding the human life span to 150, 200 or more years puts a distance between ourselves and all of our history. And it puts humans in uncharted waters. All of human wisdom on how to live a life, no longer would apply.” said Dr. Gregory Stock, the conference organizer.

Even as the scientists spoke of what might lie ahead, some drew back, nervous about public reactions and stung by their experiences when they voiced their opinions. Dr. Campisi of Berkeley said she recently gave a public lecture on aging on her campus. Afterward, she said, "a number of people came up to me and said, 'How dare you do this research? The earth is already being raped by too many people, there is so much garbage, so much pollution."' "I was really quite taken aback," Dr. Campisi said. "It was a small group but they just about nailed me to the wall."

And yet, most of the scientists at the meeting said, the question is no longer will it happen but rather when?

Kolata, Gina (March 9, 1999). *Pushing Limits of the Human Life Span*. NYT, Science Times

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Two: “Unless the aging process itself can be brought under control, the mortality trends observed from 1985 to 1995 remain consistent with the expectation that future gains in life expectancy will be measured in days or months rather than years. In an environment of optimism about modern medicine and human longevity, it is sobering to realize that life expectancy (at birth or at older ages) could actually decline for some populations because of the re-emergence of infectious diseases, social and political unrest, or natural disasters.”

Olshansky, S. J., Carnes, B. A. and Désesquelles, A (2001).Prospects for Human Longevity. *Science*, 291(23 Feb.), 1491-1492.

Three: “The goal of research on the phenomenon of cellular senescence is not unlike the goal of all research on the biology of aging. It is not to make us all immortal; that is not only impossible but also undesirable. Nor is it to stop or slow down the processes of aging, because those processes are inevitable. And because the determinants of our longevity are driven indirectly by most, if not all, of our genes, it is also very unlikely that tampering with that process is either probable or even desirable.

Instead, our goal in this research and other research in the field of aging should first be to understand why old cells are more vulnerable to disease than are young cells. Once accomplished, those differences, if exploitable, could result in a maximum 15-year increase in human life expectation. Then the underlying inexorable processes of aging will be revealed as the cause of death. Unfortunately, those processes, absent the replacement of all vital organs--including the improbable replacement of the brain--will almost certainly be inescapable.”

From the American Federation for Aging Research (AFAR)

And Four: Excerpt from **Intimations of Immortality**

by John Harris, *Science*, 288(7 Apr 2000), 59

Is it simply a design fault that we age and die? If cells were not programmed to age; if the telomeres, which govern the number of times a cell divides, did not shorten with each division; if our bodies could repair damage due to disease and aging, we would live much longer and healthier lives. New research now allows a glimpse into a world in which aging--and even death--may no longer be inevitable. Cloned human embryonic stem cells, appropriately reprogrammed, might be used for constant regeneration of organs and tissue. Injections of growth factors might put the body into a state of constant renewal. We may be able to switch off the genes in the early embryo that trigger aging, rendering it "immortal" (but not invulnerable). We do not know when, or even if, such techniques could be developed and made safe, but some scientists believe it is possible.

These scientific advances could lead to significantly extended life-spans, well beyond the maximum natural age of about 120 years. The development of these technologies may be far in the future, but the moral and social issues raised by them should be discussed now. Once a technology has been developed, it may be difficult to stop or control. Equally, fears provoked by technological developments may prove unfounded; acting precipitately on those fears may cut us off from real benefits. Scanning future horizons will enable us to choose and prepare for the futures that we want, or arm us against futures that, while undesired, we cannot prevent.

The technology required to enable extended life-spans is likely to be expensive. Increased life expectancy would therefore be confined, at least initially, to a small minority of the population even in technologically advanced countries. Globally, the divide between high-income and low-income countries would increase. Populations with increased life-spans would be unlike our aging populations. The new "immortals" would neither be old, nor frail, nor necessarily retired. We have, however, learned that ageism is a form of discrimination, and this may make it more difficult to resist the pressure for longevity.

We thus face the prospect of "mortals" and "immortals" existing alongside one another. Such parallel populations seem inherently undesirable, but it is not clear that we could, or should, do anything to prevent such a prospect for reasons of justice or morality. If increased life expectancy is a good, should we deny palpable goods to some people because we cannot provide them for everyone? We do not refuse kidney transplants to some patients because we cannot provide them for all, nor do we regard ourselves as wicked because we perform many such transplants, while low-income countries perform few or none at all.

Would substantially increased life expectancy be a benefit? Some people regard the prospect of "immortality" with distaste or even horror; others desire it above all else. Most people fear death, and the prospect of personal extended life-span is likely to be welcomed. But it is one thing to contemplate our own "immortality," quite another to contemplate a world in which increasing numbers of people live indefinitely, and in which future children have to compete with previous generations for jobs, space, and everything else.

Such a prospect may make "immortality" seem unattractive, but we should remember that it is connected with preventing or curing a whole range of serious diseases. It is one thing to ask whether we should increase people's life-spans, and to answer no; it is quite another to ask whether we should make people immune to heart disease, cancer, dementia, and to decide that we should not. It might thus be appropriate to think of "immortality" as the, possibly unwanted, side effect of treating or preventing debilitating illness.

There are numerous reasons why we should not contemplate one everlasting generation but be in favor of the regular creation of new human individuals--such as the desire to procreate, the pleasures of having and rearing children, the advantages of fresh people and fresh ideas, and the possibility of continued evolution or at least development. If these reasons are powerful, we might be facing a future in which the most ethical course is a sort of generational cleansing. This would involve deciding collectively how long it is reasonable for people to live in each generation, and trying to ensure that as many as possible live healthy lives of that length. We would then have to ensure that, having lived a fair inning, they died--either by suicide or euthanasia, or by programming cells to switch the aging process on again after a certain time to make way for future generations.

This might seem desirable, but it is difficult to imagine how it could be enforced, at least if our time-honored ethical principles remain unreformed. How could a society resolve deliberately to curtail healthy life, while maintaining a commitment to the sanctity of life? The contemplation of making sure that people who wish to go on living cannot do so is terrible indeed.

Faced with this problem, society might be tempted to offer people life-prolonging therapies only on condition that they did not reproduce, except perhaps posthumously, or that they agreed if they did reproduce to forfeit their right to subsequent therapies. However, reproductive liberty is a powerful right protected by international conventions. It would be difficult to justify curtailing it, and even more difficult to police any curtailment.

It is unlikely that we can stop the progression to increased life-spans and even "immortality," and it is doubtful that we can produce coherent ethical objections. We should start thinking now about how we can live decently and creatively with the prospect of such lives.

John Harris holds the Sir David Alliance Chair of Bioethics at the University of Manchester, UK

What is the forecast for the population over age 60?

"At the global level the proportion above age 60 is likely to increase from its current level of 10% to around 22% in 2050. This is higher than it is in western Europe today. By the end of the century it will increase to around 34%, and extensive population aging will occur in all world regions. The most extreme levels will be reached in Japan, where half of the population is likely to be age 60 and above by the end of the century." For North America the proportion above age 60 in 1995 was 16.4%. It is projected to be 30% by the year 2050.

Lutz, W., Sanderson, W., and Scherbov, S. (2001). The end of world population growth. *Nature*, 412(2 August), 543-545.

What are the ethical issues raised by the prospect of increasing human life expectancy?

- The economics of aging populations
- Over-population
- Reproduction
- Competition between generations for jobs and resources
- Equality of health care

A Summary of Human Reproduction and Longevity

- What type of research is being done on human reproduction?
- What are the motives of those doing this research?
- What is the relationship between science and medicine?

Supplemental Reading Assignment

Excerpt from **Health Care Costs**

by Rodger Doyle, *Scientific American*, April 1999

Rising medical costs are a worldwide problem, but nowhere are they higher than in the U.S. Although Americans with good health insurance coverage may get the best medical treatment in the world, the health of the average American, as measured by life expectancy and infant mortality, is below the average of other major industrial countries. Inefficiency, fraud and the expense of malpractice suits are often blamed for high U.S. costs, but the major reason is over investment in technology and personnel. America leads the world in expensive diagnostic and therapeutic procedures, such as organ transplants, coronary artery bypass surgery and magnetic resonance imaging. Orange County, California, for example, has more MRI machines than all of Canada.

Federal policy since World War II has emphasized medical technology and the widespread building of hospitals, even in rural areas. Other industrial countries, in contrast, followed the more cost-effective alternative of building up regional centers. The U.S. has long over-invested in the training of specialists at the expense of primary physicians, leading to a large surplus of specialists. Because specialists have economic incentives to perform unnecessary procedures, they may contribute to cost inflation.

Other industrial countries have managed to slow the growth in costs while achieving near-universal coverage. These include Britain, France and Italy, which have heavily centralized systems; Canada and Germany, which have decentralized systems but whose provinces play a key administrative role; and Japan, which combines strong national policy making with health care administration left largely in private hands. In each instance, central governments imposed strict fiscal controls even though they resulted in long waiting times for elective treatment and considerable delays in seeing specialists.

President Bill Clinton attempted to impose central fiscal controls as a part of his 1994 health care plan but was unable to put together a solid supporting coalition. Insurance firms, pharmaceutical companies, small business operators and academic medical centers were opposed to the plan. Labor unions and Medicare beneficiaries generally favored it but lobbied vigorously for changes that would improve their benefits. Republicans opposed the plan on the grounds that it called for new taxes.

According to political scientist Lawrence R. Jacobs of the University of Minnesota, universal access is a key to the success of other countries in imposing fiscal controls because it helps to lessen friction between groups. The American system encourages discord, for example, between health care insurers and high-risk people whom they exclude from coverage. Americans who receive adequate care through employers have little economic interest in seeing coverage extended to the more than 43 million Americans now uninsured.

In recent years U.S. health care expenditures as a percent of gross domestic product have leveled off, probably as a result of the expansion of managed care. The projected increase to 16.6 percent of GDP in 2007 shown on the chart assumes that managed care will grow more slowly, that increasing consumer income will boost the demand for medical services and that medical cost inflation will accelerate. But the period of greatest stress will come after 2010, when baby boomers begin to retire. Not only will federal budgets be strained, but also employers, already paying far more in medical costs than foreign competitors, will be put at a further disadvantage in world trade.

How can the federal government ever assert fiscal control over medical costs? Victor R. Fuchs of Stanford University, a longtime observer of the medical economy, believes that comprehensive reform of the U.S. medical system will come only after a major political crisis as might accompany war, depression or widespread civil unrest. Such a crisis might arise as medical costs reach ever higher and threaten Social Security, Medicare and other popular programs; there could be political upheaval of such magnitude that medical reform will seem to be the easy solution.

National Institutes of Health

Press Briefing, FY 2001 President's Budget

The National Institutes of Health (NIH) serves the American public through the support and conduct of medical research. We have reached the end of a century in which the average life expectancy in the United States has increased by nearly 30 years–an accomplishment realized, in part, by research-based improvements in health. Continued improvements in the practice of medicine and health are possible, if we are prepared to take advantage of the achievements in fundamental science and informatics, including advanced computing and imaging.

In FY 1999 and FY 2000, Congress provided dramatic increases in the NIH budget, boosting our power to transform laboratory and clinical research into effective treatments and new approaches to the prevention of our most deadly diseases. As a result of these generous increases in our budget, the Institutes and Centers (ICs) at the NIH have many new initiatives underway, all of which will be continued in FY 2001 and beyond. This ramped-up investment in medical research will pay real dividends in the years to come–dividends in the form of new scientific knowledge, new treatments, new diagnostic tools, new cures, and new ways to prevent disease before it strikes.

Budget for fiscal year	1999	2000	2001
	actual	14% increase	5.6% increase
NIH Total	$15,633,189,000	17,849,235,000	18,849,235,000
National Institute on Aging	599,720,000	687,861,000	725,949,000

The NIH budget for 1997 was $12,750,000,000. This means that **from 1997 to 2001 the NIH budget increased 50%**.

Aging is a Major Focus for Research Funds

"In the year 1999, the budget for the National Institutes of Health was ~15 billion dollars. The research and development budgets of the major pharmaceutical companies were in excess of $20 billion. At the current time the majority of those funds is focused on the major killers: heart disease, cancer, diabetes, asthma, etc. Most of these diseases have strong genetic components. It will be possible, circa 2005, to use gene-chips to scan people for the genetic mutations that lead to these diseases. Armed with that information we will be able to intervene with drugs or gene therapies that correct these diseases before they cause significant damage. Once these diseases are fully understood and therapies are in the pipelines, major funding will move to the only remaining "disease" -- aging. So we can look forward to billions of dollars in research dollars going into understanding and developing interventions for aging processes."

"These facts and projections point toward a rapid understanding of the aging process and an application of technologies to significantly extend life-span. These technologies will be developed and applied faster than we age. The net result will be an unlimited maximum life-span. Will people live forever? Not as biological machines. The maximum average life-span will be determined by the rate of accidents which result in damage to the brain which is unrepairable. Depending on the accident rates for fires, earthquakes, floods, severe car/train/plane crashes, etc. the average life-span will be more than 100 years."

Robert Bradbury, Founder and President of Aeiveos Corporation, Seattle, WA.

Unit Seven: The Human Impact on the Earth

Introduction: The beginning of the twenty-first century is a critical moment in our history. Human beings using the tools created by science and technology have become the dominant force on this planet. But our domination of the world is unstable and undirected. If we take up Buckminster Fuller's challenge to be the architects of the future and not its victims, then the decisions we make now will have long reaching effects for generations to come. It is, therefore, time for a careful examination of the state of our world and what we want for the future.

Topic One: The History of Human Population Growth

Humanity's effect on the Earth's environment has many components. One of which is the sheer size of our population. But to understand how our population has changed the world we need to know more than just its current size. We need to know its history.

The History of the Human Population

The population history of modern humans can be broken into three phases:

• Population increase caused by the dispersal of modern humans out of Africa roughly from 60,000 to 11,000 years ago

• Population increase caused by the invention of agriculture starting between 12,000 and 11,000 years ago and extending to the 1500s

• Population increase caused by the advent of modern science and technology from the mid-1500s to the present

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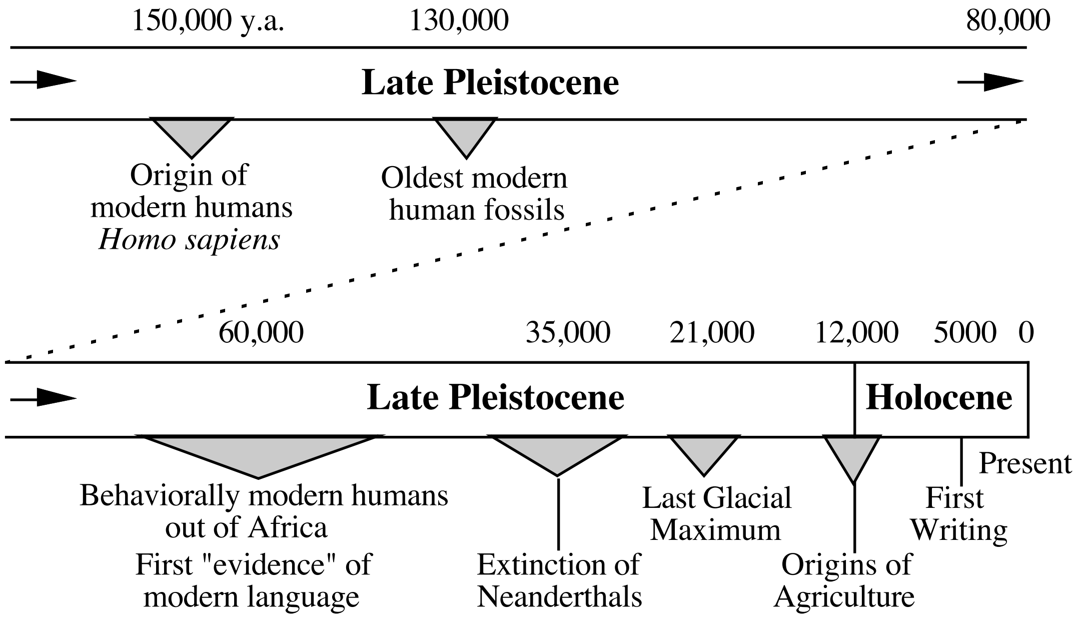
Late Pleistocene to the Present



Phase One: The Dispersal of Modern Humans out of Africa

During the Middle Paleolithic (200,000 to 44,000 y.a.) “early human populations were exceptionally small, even by later Paleolithic standards and [it appears] that early Middle Paleolithic humans did not spend much time foraging in any one vicinity.” (Stiner 1999) At some point, however, early modern humans in Africa developed new hunting technologies which lead to their expansion out of Africa ~ 60,000 years ago. This expansion into virgin territories, together with new hunting technology, caused the first period of exponential growth in human numbers. Although the human population did grow exponentially during this period, densities were kept low by the combination of reliance on hunting and the violent climate swings of the Late Pleistocene.

Phase Two: The Invention of Agriculture

The second major pulse in human population growth is associated with the invention of agriculture. But if you have been successful as hunters and gathers for thousands of years, why invent agriculture? The answer lies in the combination of three events.

First, the climate changed 11,500 y.a.. Why didn’t humans invent agriculture a hundred thousand years ago? The first modern humans were identical to us and, therefore, surely intelligent enough to do so. Why did the invention of agriculture and the population explosion that followed have to wait until 12,000 to 10,000 years ago? Part of the answer is in the weather.

All during the Pleistocene Ice Age violent weather was the norm, and not until the interglacial climate shift 11,500 years ago did the violent swings in climate settle down to our present calm state. Peter Ward provides this picture:

> "The analysis of oxygen isotopes from the Greenland ice cores have shown that the climate over the past 250,000 years has changed frequently and abruptly; the magnitude of the global temperature changes has been far greater, and their intervals far shorter, than anyone imagined. Dr. J. White of the University of Colorado, noted in a recent summary that between 200,000 and 10,000 y.a., average global temperature had changed as much as 18° F in a few decades. The current average global temperature is 59° F. Imagine that it suddenly shot up to 75° F or sank to 40° F in a century or less. At a minimum, these sudden changes would create catastrophic storms of unbelievable magnitude and fury. Yet such changes were common until 10,000 years ago. Imagine a world where storms that dwarf Hurricane Andrew lash the continents not once a century but several time each year, every year. Imagine a world where tropical belts are suddenly assaulted by snow each year. This was our world until 10,000 years ago, when, according to the studies of the Greenland ice cores, a miracle happened: The sudden shifts in the weather stopped." (Ward 1997)

Second, modern humans in area after area reached their density limit as hunters. By the Upper Paleolithic (44,000 to 19,000 y.a.) hunting pressure had forced people's attention from slow moving prey to fleeter prey types. This is, after all, what happens when you spread out and then kill off your preferred (which usually means easier to catch) prey species. Once your population spreads out and fills all available habitats, however, you can't do it again (this is the notion of demographic packing). So if your population increases, it must increase your density per unit area, thereby putting even greater pressure on food resources. "Mobility was the preferred solution to local resource scarcity throughout much of prehistory. Any loss of mobility options is a grave matter for people who live by hunting and gathering. The changes in prey species during the Mediterranean Paleolithic nonetheless indicate demographic packing and associated reductions in mobility." (Stiner 1999)

And third, by 11,000 y.a. modern humans had killed off the Pleistocene megafaunas, the mammoths, mastodons and ground sloths along with many other large species, of both the old and new worlds. In North America 73% of all genera weighing more than 100 pounds went extinct between 12,500 to 11,000 y.a., not long after humans arrived on the continent (Ward 1997; Flannery 1999). "But Australia suffered the most severely of all the continents, losing every terrestrial vertebrate species larger than a human," (Flannery 1999). Most telling of all is that the Australian extinctions again coincided with the arrival of humans, only this time around 50,000 years ago during a period of climate stability, and at least 30,000 years before humans reached the Americas.

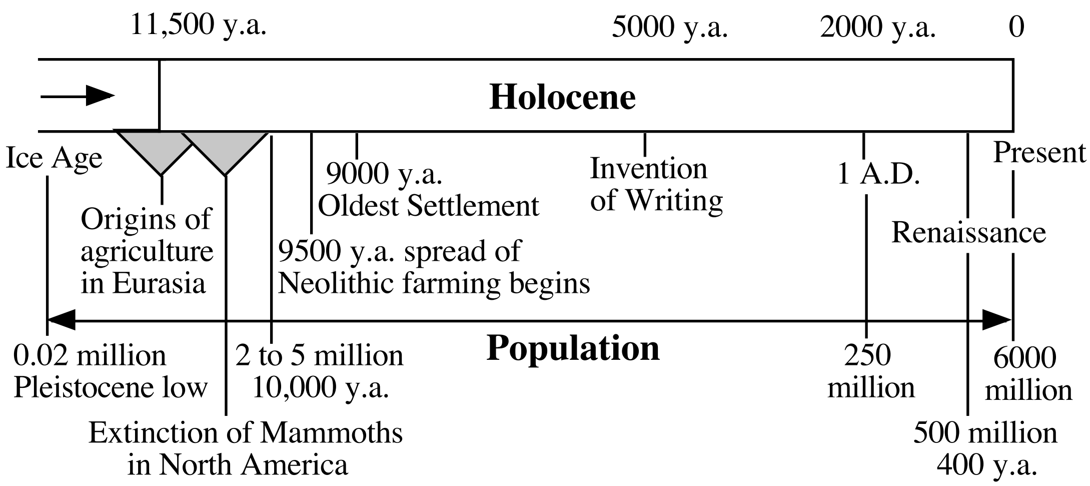
On the one hand the extinction of the Pleistocene megafauna put selective pressure on early human hunters to find other food sources, at the very least smaller game, whereas the climate change allowed that new food source to be cultivated plants. An example in support of this hypothesis comes from Pringle:

> "In a layer dated to at least 13,000 y.a. the [rice] phytoliths show that hunter-gathers in the cave were dining on wild rice. But by 12,000 y.a., those meals abruptly ceased --

Zhao suspects because the climate became colder and the wild grain, too tender for such conditions, vanished from this region. Studies of the Greenland ice cores have revealed a global cold spell called the Younger Dryas from about 13,000 to 11,500 y.a.. As the big chill waned, however, rice returned to the region. And people began dabbling in something new around 11,000 y.a. -- sowing, harvesting, and selectively breeding rice." (Pringle 1998)

The invention of agriculture caused the second period of exponential growth in the human population by allowing increases in population density per unit area rather than range expansion. Note that new studies of the origin of agriculture clearly place the origin at the interglacial climate shift 11,500 years ago.

The Holocene Epoch



Phase Three: The Scientific Revolution

Survival Value & Control

There is tremendous survival value in having reliable knowledge about our world. With it comes control over nature and for the first time in human history we are no longer at the mercy of an indifferent universe. The most significant change in our world in the last four hundred years is that science and technology have immensely extended our control over natural events. But with this control has come an explosion in our population size as the limiting factors of disease and famine have one after another been removed.

Human Population Increase

Based on genetic evidence, at some point in the Late Pleistocene the ancestral population of humans dropped to a low of ~ 20,000 individuals.

From this Late Pleistocene population modern humans spread throughout the world and then invented agriculture so that by the year 1 A.D. the human population had reached 1/4 billion. It then took --

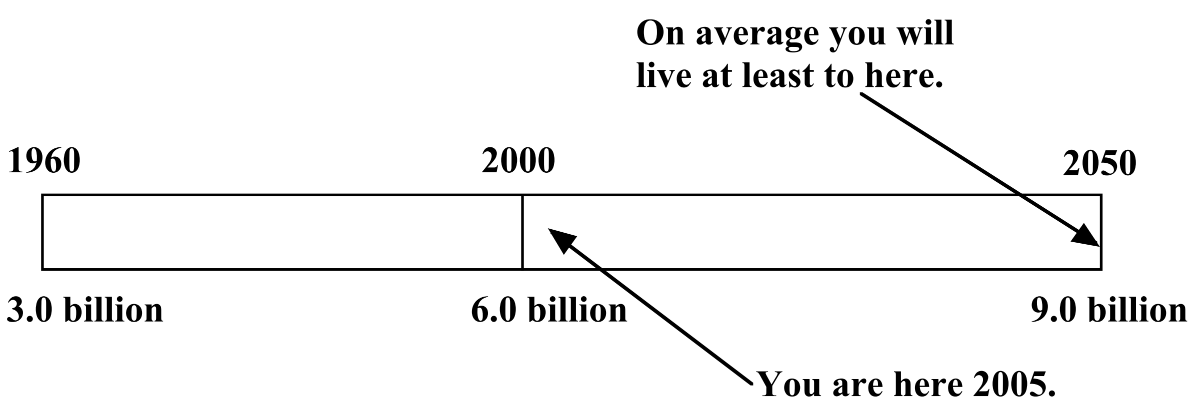
from 1 A.D. to 1600	-- to reach 1/2 billion	(1600 years doubling time)
from 1600 to 1830	-- to reach 1 billion	(230 years doubling time)
from 1830 to 1930	-- to reach 2 billion	(100 years doubling time)
from 1930 to 1960	-- to reach 3 billion	(30 years to add a billion)
from 1960 to 1974	-- to reach 4 billion	(14 years to add a billion)
from 1974 to 1987	-- to reach 5 billion	(13 years to add a billion)
from 1987 to 1999	-- to reach 6 billion	(12 years to add a billion)

(after Cohen 1995)

What are the projections for population growth in the future?

The projections show that it is highly likely that by the year 2050, the human population will reach 9 billion.

Why is your generation different?



Unit Seven: The Human Impact on the World

Topic Two: How many people can the Earth support?

What are the ethical issues that follow from the explosive growth of the human population? The questions which focus these ethical issues are: Is the Earth already over-populated? And if not? How many people can the Earth support?

Lifestyles and Per Capita Consumption

Humanity's impact on the natural world can be understood by looking at the relationships between population size, per capita consumption, and lifestyles.

- Multiplying the number of people times their rate of consumption gives the total human impact on the Earth.
- Lifestyles determine per capita consumption.
- Affluence and technology determine possible lifestyles.

As a result, per capita consumption varies dramatically between humans depending on their affluence and access to technology and the lifestyle they either choose or are forced to live.

How much do we consume now?

"Human beings use 40 percent of annual terrestrial plant growth,

60 percent of accessible freshwater runoff, and

35 percent of the ocean's continental shelf productivity."

from Stuart Pimm's *The World According to Pimm: a scientist audits the Earth* (2001)

What relative portion of total world consumption do Americans consume?

Consumption as measured by our "ecological footprint" which represents the productive area of the Earth required to support the lifestyle of one individual in a given population:

U.S.A.	30.2 acres per person
Germany	15.5
Brazil	6.4
Indonesia	3.7
Nigeria	3.2
India	2.6

In other words, on average, each American consumes from 6 to 12 times more of the worlds resources than an average person in India.

The central questions are:

1. Can we sustain this level of consumption or are we degrading the Earth's ability to support even this current level of consumption?

It is estimated that humanity uses one-third more resources than nature can sustainably replenish. By this measure, the world is already overpopulated. The estimate is that 2 to 3 billion humans could be supported sustainably at the level of consumption of Americans.

2. How much will we consume fifty years from now when our population reaches 9 billion?

But we have choices

The answer to how many people can the Earth support depends on the lifestyle we choose. In America our affluence and technology make many different lifestyles possible. Out of all of the possible lifestyles available to us, we can choose the one that will create the future we want. But what do we want?

- Do we want as many people as possible on the Earth at one time?
- Or do we want a sustainable world where, over the history of humanity's tenure on Earth, the greatest number of lives could be lived?
- Do we want a certain level of quality to our lives?
- And if so, what increases the quality of our lives?

The answer to the carrying capacity debate is dependent upon the choices we make about our personal reproduction, our lifestyles and consumption, and our political, economic, and social priorities. As Paul and Anne Ehrlich noted in *The Stork and the Plow*:

"Earth can support a larger population of cooperative, far-sighted, vegetarian pacifist saints than of competitive, myopic, meat-eating, war-making typical human beings. All else being equal, Earth can hold more people if they have relatively equal access to the requisites of a decent life than if the few are able to monopolize resources and the many must largely do without.

The problems of population, social and economic inequity, and environmental deterioration are thus completely intertwined."

Unit Seven: The Human Impact on the World

Topic Three: Biodiversity

What is the human impact on biodiversity?

How many species are there?

We currently have identified and named approximately 1.5 million species. But even that is only an estimate. There is no catalog or computer data base for the species we have already identified.

This number includes only about 45,000 species of vertebrates of which there are approximately 10,000 species of birds, and 5000 species of mammals. These are the species we know best, but birds and mammals, indeed all vertebrates, represent only a small fraction of named species.

How many species are there that haven't been cataloged?

The estimates for the total number of species range widely from 7 to 30 million species. The most conservative of these estimates is 10 to 12 million. Using 10 million species, it will take scientists, at their current rate, until the year 3000 to identify and name all the species on Earth.

Isn't species extinction natural?

Yes it is. The estimate of the number of species that have lived on Earth and have gone extinct is 99%. Ninety-nine percent of all the species that have ever existed have gone extinct. But that shouldn't surprise you if you think of species as individuals in a population (a very serious proposal by very serious scientists). It is easy to understand that there have been millions upon millions of humans that have lived and died in the past. Current estimates are that 106 billion humans have lived beginning 50,000 years ago. With 6.18 billion alive today that gives 5.7% of all the humans on Earth for the last fifty thousand years are alive now.

The issue is not that species go extinct, but at what natural rate do they go extinct?

To answer that question we need to know the average lifespan of species.

What is the average lifespan of a species?

-- 1 million years --

The long and short of it is that Stuart Pimm took six pages of his book to explain how this number is arrived at, so, in the interest of time, I refer you to his book -- *The World According to Pimm: a scientist audits the Earth* (2001).

What then is the natural extinction rate for all species?

-- 10 per year for all species --

With an average lifespan of 1 million years that would mean that out of a million species, on average, one would go extinct every year. If there are 10,000 species of birds that means that the natural extinction rate for birds is one species extinct every 100 years or one per century. These numbers assume a stable "population" of species where new species are evolving to replace old ones constantly over time.

The estimate for just birds is one natural bird extinction worldwide every 100 years.

"That's it. You are not allowed even one more bird extinction. Just one more, anywhere in the world within a century, would be cause to accuse humanity of the crime of shortening species' lifetimes." (Pimm 2001)

How many species have humans already driven to extinction? Or to put it another way:

What is our "track record" for stewardship of life's biodiversity?

The Pleistocene Over-kill

In North America 73% of all genera weighing more than 100 pounds went extinct between 12,500 to 11,000 y.a., not long after humans arrived on the continent (Ward 1997; Flannery 1999).

Asia and Europe also lost their Pleistocene megafauna, the mammoths are a case in point, but much early than the Americas.

Australia suffered the most severely of all the continents, losing every terrestrial vertebrate species larger than a human," (Flannery 1999). Most telling is that the Australian extinctions again coincided with the arrival of humans, only this time around 50,000 years ago during a period of climate stability, and at least 30,000 years before humans reached the Americas.

That humans caused these extinctions is not proven. Rather, it is a working hypothesis that so far accounts for all the evidence. But can we prove humans have caused unnatural rates of extinction in the past?

Islands

What is the history of human settlement on islands?

It is estimated that on the Hawaiian islands alone there were 80 to 90 species of birds, now known only from fossils, that went extinct in the thousand years between the arrival of the Polynesians and the arrival of Europeans. In addition it is estimated that:

> "As the Polynesians colonized the Pacific from New Zealand to Hawaii and east to Easter Island they exterminated 1000 to 2000 species of birds." "Using the lower estimate, this comes to 10 percent of the world's bird species. The extraordinary conclusion is that double-digit human caused extinction percentages are part of Earth's recent history, not merely wild speculations about its future. These numbers mean that the rate of extinction was, an unnatural, one species every *few years* -- not the expected one species per *century*." (Pimm 2001)

The story is not over.

Since James Cook found the Hawaiian Islands in 1778, eighteen species of birds have gone extinct. That is almost one extinction every decade for the last 200 years.

The message is clear: Bird species are lost at the rate of about one per year. That is about a 100 times faster than the benchmark of one extinction per 100 years among the 10,000 species of birds.

But what of already endangered species? What if they are added to the total?

What is the current estimate for the rate of human caused species extinction?

-- 1000 times the natural rate of extinction --

Stuart Pimm

"The fossil record suggests that most species live 1 million years or more. The DNA evidence provides confirmation. So the destined hour for species will be measured in the millions of years. At this rate only 1 species in 1 million or more should encounter its natural end each year.

The unnatural number is already closer to 1 species in 10,000 -- a number 100 times larger. Looking at the numbers of species that we have already wounded and making a grim assessment of how long they are likely to live, we find that the number is closer to 1 in 1000, which is 1000 times larger than the natural rate. Humanity's impact has reduced species' lifetime form a metaphorical hour to a minute, and it soon may be a matter of seconds. These reductions in species' lifetimes are not only large but ubiquitous. They happen throughout the planet's diverse ecosystems." (2001)

The Future of Biodiversity -- Nature's Eggs in a Few Baskets

Hot Spots -- areas where endemic species with small ranges are concentrated

"Not all hot spots of biodiversity are in the tropics, but most are. Hot spots can be extraordinarily concentrated; thousands of species may be found within an area the size of a U.S. eastern state. Species with small ranges are particularly vulnerable to impacts. Nature has put her eggs in a small number of baskets, and we are in danger of dropping them. It is estimated that only about 2 million of the original 17 million square kilometers of hot spots remain."

"Most -- perhaps two-thirds -- of the remaining species, those not found in hot spots, are in tropical moist forests in the Amazon, Congo, and insular Southeast Asia. Ten percent of these forests are being cleared per decade, perhaps more, and certainly the rate is accelerating." (Pimm 2001)

The Future of Biodiversity -- The Bottom Line

Adding the species endangered in hot spots to those endanger in tropical moist forests,

we could lose between 1/3 and 1/2 of all species within the next hundred years.

What are the human activities that cause species extinctions?

Drivers of Change

Population size and per capita consumption are assumed to be the two greatest drivers of global environmental change. Humans currently appropriate ~ 40% of the production of terrestrial ecosystems and ~ 60% of usable freshwaters, have doubled terrestrial nitrogen supply and phosphorus liberation, have manufactured and released globally significant quantities of pesticides, and have initiated a major extinction event.

Global population, which increased 3.7-fold during the 20th century, to 6 billion people, is forecast to increase to 7.5 billion by the year 2020 and to about 9 billion by 2050.

Constant-dollar global per capita gross domestic product (GDP) increased 4.6-fold in the 20th century and is projected to be 1.3 times current levels by 2020 and 2.4 times current levels by 2050.

Excerpt from **Global Biodiversity Scenarios for the Year 2100**

by Osvaldo E. Sala, O. E., et al,
Science, 287(10 March 2000), 1770-1774

"Scenarios of changes in biodiversity for the year 2100 can now be developed based on scenarios of changes in atmospheric carbon dioxide, climate, vegetation, and land use and the known sensitivity of biodiversity to these changes. This study identified a ranking of the importance of drivers of change, a ranking of the biomes with respect to expected changes, and the major sources of uncertainties.

For terrestrial ecosystems, land-use change probably will have the largest effect, followed by climate change, nitrogen deposition, biotic exchange, and elevated carbon dioxide concentration."

Excerpt from **Forecasting Agriculturally Driven Global Environmental Change**

by Tilman, D. et al. *Science*, 292(13 April 2001), 281-284

"During the next 50 years, which is likely to be the final period of rapid agricultural expansion, demand for food by a wealthier and 50% larger global population will be a major driver of global environmental change.

If the past links between the global environmental impacts of agriculture and human population and consumption continue:

• one billion hectares of natural ecosystems would be converted to agriculture by 2050. This is an area larger than the continental U.S..

• This would be accompanied by 2.4 to 2.7-fold increases in nitrogen- and phosphorus-driven eutrophication of terrestrial, freshwater, and near-shore marine ecosystems, and comparable increases in pesticide use.

• This eutrophication and habitat destruction would cause unprecedented ecosystem simplification, loss of ecosystem services, and species extinctions.

• The efforts required to meet the demands for food of an additional 3 billion people in the next 50 years will be immense even if little or no effort is made to preserve biodiversity.

Unit Eight: Ethics and Equity in the 21st Century

Topic One: The Haves and the Have Nots

The Wealth and Poverty of Nations and People

The widening gap between the rich and the poor

Despite unprecedented economic growth during the last part of the 20th century, the gap between rich and poor nations and people widened significantly.

• In 1998, the richest 20 percent of the world's population controlled 86 percent of the wealth, while the poorest 20 percent controlled only 1.1 percent.

• This is a gap of nearly 80-1, up from a 30-1 gap in 1960.

• The middle 60% of people also saw their share of world income decline during this period.

• Average global per capita income has now passed $5000U.S.per year but more than 1300 million people still live on less than $1U.S. per day.

• The United Nations Development Program estimated in 1999 that more than 80 nations have lower per capita incomes than 10 or more years ago. In 55 countries per capita incomes are still going down.

• The richest 225 people controlled as much wealth as the poorest 2.5 billion people.

• And the richest three people controlled more wealth than all the least developed nations and their 600 million people.

America the Haves

Americans are at the head of a chain of consumption that has left the planet in a state in which its richest 20 percent of people own 87 percent of all vehicles and consume 84 percent of all paper, 58 percent of all energy and 45 percent of all meat and fish, according to the United Nations.

The United States is home to 54 percent of the world's individuals with ultra-high net worth, persons with investable assets exceeding $30 million, according to Merrill Lynch and Gemini Consulting.

Yet the United States is the most skinflint of industrialized nations. While Norway, for instance, gives out $285 per capita in development assistance, the United States gives out only $30, according to the United Nations.

Africa the Have Nots

• Africa is the only continent on which poverty is expected to rise during the next century.

• An estimated 500 million hectares of land have been affected by soil degradation since about 1950, including as much as 65 per cent of agricultural land.

• As a result of declining food security, the number of undernourished people in Africa nearly doubled from 100 million in the late 1960s to nearly 200 million in 1995.

• Africa lost 39 million hectares of tropical forest during the 1980s, and another 10 million hectares by 1995.

• Fourteen African countries are subject to water stress or water scarcity, and a further 11 will join them by 2025.

• A tenfold reduction in resource consumption in the industrialized countries is a necessary long-term target if adequate resources are to be released for the needs of developing countries in Africa and elsewhere.

Excerpt from **Income Inequality in the U.S.**

by Rodger Doyle, *Scientific American* June 1999

For about three decades--roughly the period from the early 1940s to the early 1970s--the U.S. became progressively more egalitarian. This was a time of rapidly rising productivity and rising real wages. But by the early 1970s, productivity growth slowed and real wages declined, at least for the unskilled. Although average household income in real dollars rose by 41 percent from 1967 to 1997, those with low incomes--the two lowest groups on the chart--benefited little. Of course, from year to year, some households moved up the income scale, whereas others moved down.

The growing inequality of the past few decades cannot be blamed solely on globalization of trade, although some economists believe it is the most important factor depressing wages and threatening the jobs of the less skilled. Other economists, including those in the Clinton administration, argue that technology, particularly computerization, is the chief villain. (But recently there have been signs that computers and the Internet may finally be contributing to an increase in U.S. productivity growth, which historically seems to coincide with rising equality.) The decline of American trade unions, which traditionally have reduced the gap between worker and manager incomes, is also a factor, as is the related drop in good-paying manufacturing jobs. Beginning in the 1980s, the supply of college graduates grew slowly, which led to a shortage of better-educated workers and consequently an increase in their earnings advantage over the less skilled. The rising number of single-parent households also contributed to inequality, and the influx of women into the job market may have depressed wages of the unskilled by increasing the supply of labor. In addition, the unskilled suffered from competition with immigrants and from the decline in the real value of the minimum wage.

Another reason for rising inequality was the dramatic surge, beginning in the early 1980s, in the share of income going to the top 5 percent of households. Lower tax rates introduced by the Reagan administration probably also contributed to inequality.

Income inequality is greater in the U.S. than in Europe--some of the most striking differences are found among the lowest paid. Globalization and new technology also affected the distribution of income in Europe, but in most cases, inequality did not rise as much as in the U.S. Countries with strong labor union movements were able to moderate the growth of inequality. In European countries the wage premium for a college education is less than it is in the U.S.

On average, the U.S. in the 1990s enjoyed greater growth and lower unemployment than did major European nations. Is the U.S. performance the result of greater inequality, with bigger rewards to the rich, who typically invest much of their surplus in job-producing enterprises? Is the lower growth in European countries the result of spending on social welfare, rather than investing in job-creating enterprises? Does the equalizing effect of stronger unions in most European countries contribute to lack of creativity and competition? Economists do not agree on the answers to such questions, but they do agree that investment in education, particularly for low-income children, would reduce income inequality.

Even in the richest country in the world the trend is toward greater inequity.

Consider the following facts…

If the minimum wage had risen at the same pace as American productivity since 1968, it would be $13.80 an hour.

If the minimum wage had risen at the same level pace as executive pay since 1990, it would be $25.50 an hour, not $5.15.

Twenty-nine percent of American families make less than what the Economic Policy Institute estimates is needed to meet basic needs - a national median of $33,551.

The median wage of child-care workers is $6.91 an hour. The median wage of parking lot attendants is $6.89. Preschool teachers average $9.43. Animal trainers average $12.39.

In 1978, 70 percent of workers in the private sector were covered by employer-provided health insurance. By 1998, the figure had dropped to 62.9 percent.

In 1979, 40.7 percent of the lowest-income workers in the private sector were covered by employer-provided health insurance. By 1998, the figure had dropped to 29.6 percent.

Reciprocity — the principle of equal consideration of the interests of all.

Ethical cooperation between rational like-kinds can be based on the logical assumption that the desires an individual has are the same as others like themselves.

Reciprocity recognizes that all members of a society should have an equal share in the benefits and obligations of their society. The lesson from history is that when a society marginalizes part of its citizens, it dooms itself to failure.

But the logic of reciprocity applies to more than societies; it applies to humanity as a whole. We cannot expect the people of the underdeveloped nations of the world to indefinitely endure poverty and starvation while more than one billion people in the developed nations of the world are now overweight. In the US 61% of adults are overweight, and 27% are obese.

If we do not provide an equal share in the benefits and obligations of this world for all of humanity, we should not be surprised at the outcome. And that outcome is war.

Supplemental Reading Assignment

Excerpt from **U.S. Needs to Assess Role in World Scheme**

by Myron Wlaznak, Bellingham Herald, 9 November 2001, Opinion

I grew up ducking and covering in anticipation of a bright light exploding outside my schoolroom window. The city's civic center was where I was supposed to go to survive a direct nuclear hit -- one could stay there until the all clear was given.

Starting in the '60s, I began watching a dirty little war in a far away unknown jungle. Each night the news would bring me my daily dose of live combat, casualty figures, political proclamations and instant analysis. The television was right there when the action happened. As I grew closer to 18, I developed a detached indifference to the daily dose and headed off to college.

My school was not heavily involved in the demonstrations; perhaps we were apathetic, but the war was always the hot topic of discussion. The nightly news took on special significance when the body bags arrived at our town, when someone I knew came home to full military honors.

When I was inducted, the nightly news assured me that the war was over, just a matter of time now. I spent almost a year in training but some went to war after only 16 weeks of soldiering. I wonder what happened to them. I spent three safe years stateside training troops. I heard all the stories, talked to many who returned, looked into their eyes. Some of those I trained didn't come back from a war that was all but over. As a civilian again, I watched the final tragic episodes on the evening news, listened to the analysts and the political pundits as they told us to get on with our lives.

In my time, I've watched the same Arab-Israeli war several times now. I've watched invasions of Caribbean islands; failed hostage rescue attempts in the desert; the Mother of All Wars in the Middle East; genocide, then peacekeeping in Africa and the Balkans; the religious war in Ireland; clandestine guerrilla wars in South America; the Gulf War, the war on drugs, the war on poverty, and now the war on terrorism. That is a lot of war in just over 50 years and those are only the ones that made the evening news!

One would hope that humanity learned something from this past 50 years of incessant war. Add in the two great wars and one police action, certainly humanity should have learned something in this past century. Apparently, sadly, we have not. The new millennium follows in the same calamitous missteps. Despite the dull resignation of so many helpless people to their fate, the utter hopelessness of starving, parentless children, total destruction and devastation seen 24 hours a day, humanity still hasn't found a way to prevent, cure or eliminate the folly of war. Perhaps, after watching war live for an entire lifetime, we never will -- a truly sobering thought.

What is the path out of this dilemma? Is it humanity's fate to repeat this cycle of perpetual war until the end of time? Some would say yes. Certain beliefs condemn us to this accursed fate. There is nothing we can do to change our sorry lot. Other beliefs command us to turn the other cheek, make peace with our enemy. Yet the adherents to these beliefs have a history of violence that rivals this past century. What are your beliefs? Have you thought about it? Sept. 11 should be an awakening for us all.

Perhaps it is time to deliberate our role in the world scheme. Currently we may be the material, economic and military leader but is that enough? Can we achieve peace by having the greatest wealth, exporting our financial acumen to the four corners of the globe, being the world's police force? It hasn't worked so far, I doubt if it ever will.

I certainly don't presume to have right answers, what I do have are more questions now than I ever had.

Perhaps it is not yet the right moment to consider these kinds of thoughts. Perhaps we need to mourn a little while longer, but we do need to weigh these questions even as we ponder our response; otherwise the next hundred years will mirror the past.

Bellingham Herald community columnist Myron Wlaznak is a retired business executive.

Unit Eight: Ethics and Equity in the 21st Century

Topic Two: The Way Forward

In this course we have looked at many of the social, ethical issues that exist between science, technology, and society in our world. As we did so, it was a goal to provide you with the best information about these issues without making judgments about them.

It would be unfair, however, to leave you without some ideas on how we could move forward in resolving these issue. What follows then are suggestions on how we might proceed in dealing with the seemingly intractable problems we have seen.

Point Number One: The problems of population, social and economic inequity, environmental deterioration, and war are completely intertwined.

Point Number Two: No one gets to pick where they are born.

Point Number Three: Start with the basics

Basic Number One: Pure drinking water for all of humanity

Basic Number Two: Adequate sanitation for all of humanity

Basic Number Three: Adequate food for all of humanity

Basic Number Four: Adequate shelter for all of humanity

Basic Number Five: Access to basic medical care for all of humanity

Basic Number Six: Access to basic education for all of humanity

Point Number Four: Adequate and basic are not mysterious words. They simply mean that which sustains life. Inadequate shelter is shelter that does not protect you from the elements. Basic health care is the most cost effective care we have -- the greatest benefit for the greatest number. Basic education is literacy.

Basic Number Seven: Equal treatment for all of humanity

No class (economic or social), ethnic group, or gender of human beings should have any rights, obligations, or status other than those possessed by all classes, ethnic groups, or genders.

Point Number Five: Don’t stop until we get the basics done. Only then should we worry about what else we ethically need to do.

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