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# The Genome: Controversy for All Times

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"Human salvation lies in the hands of the creatively maladjusted"

Martin Luther King, Jr., May 17, 1956

One topic that seems to raise visceral reactions from scientists to everyday people is the notion of science beng in possession of the ability to understand and manipulate genes. Since humans are deemed fallible creatures, how will knowledge so germane to the crux of our very existence, escape the ravishes of ego, greed, domination, power, control, politics, and corruption.

In approaching any topic, I always find it salubrious to begin with a basic question. Questions help us frame a discussion, or the issues surrounding a discussion. Questions also help students to focus upon that which is to be presented. In this instance let us begin with: What is a genome? It is the total set of genes carried by an individual or cell (1). All parents pass on genes to their offspring. This is what is commonly referred to as heredity. Various characteristics are passed from generation to generation (i.e. height, hair color, blood type, and a multiplicity of diseases). Genes are located in every cell, on tiny threadlike structures called chromosomes. Each chromosome contains a single molecule of a chemical substance called DNA, or deoxyribonucleic acid. One of these molecules may contain as many as one thousand genes (2). Human beings have forty-six chromosomes. The Genome Project, sponsored by the United States Department of Energy, seeks to determine what each and every gene in the body does.

The Human Genome Initiative is a worldwide research effort that has the goal of analyzing the structure of human DNA and determining the location of all human genes. In parallel with this effort, the DNA of a set of model organisms will be studied to provide the comparative information necessary for understanding the functioning of the human genome. The information generated by the human genome project is expected to be the source book for biomedical science in the 21st century. It will have a profound impact on and expedite progress in a variety of biological fields, including those such as developmental biology and neurobiology, where scientists are just beginning to understand the underlying molecular mechanisms. The analysis and interpretation of the information will occupy scientists for many years to come. Thus, the maximal benefit of the human genome project will only be achieved if it is surrounded by research efforts that are focused on understanding and taking advantage of the human genetic information (3).

The area we have now labeled as genetics, didn't become a major area of study until around 1865. *The Gene*

*Wars* by Robert Cook-Deegan, sets forth the following history on Genetics: Greg Mendel, with his experiments on peas, noted certain characteristics, "factors" as he called them, were passed on from each parent. In 1877, chromosomes were first observed inside cells. Walter S. Sutton (a medical student at the time) teamed up with Edmund B. Wilson (at Columbia University) proposed in 1902 that chromosomes carried Mendel's hereditary factors. Later, Nettie M. Stevens and Wilson looked at the factors on X and Y and tied it to gender. In 1906, an English scientist, William Bateson broke ground on the study of inheritance "genetics." Thanks to independent "coinage" Mendel's hereditary factors became "genetics." Consequently, by 1910, the field had a name, and specific elementary objects to study. Robert Cook-Deegan further states that Mendel's work, though published in 1866, didn't get its just recognition for almost thirty-five years because its relevance to the dominant biological controversy of its day-evolution-was not immediately apparent (4).

Cook-Deegan states that in 1900, three scientists from Holland, Germany, and Austria again revisited Mendel's work. As a direct result, Mendelian genetics was off and running. The science community would be locked into an often-contentious debate on genetic mechanisms to explain variations among generations. Some of the intensity of the debate waned in the 1920's and 1930's thanks to theoretical population genetics. This field gave statistical analysis of variations with the study of inheritance; to explain how small genetic changes "mutations" could work with natural selection to explain evolution (5).

As the field of genetics continued to expand, Thomas Hunt Morgan (California Institute of Technology) became the forerunner in understanding the role of chromosomes play in disseminating traits in fruit flies (Drosophila melanogaster) and other species. His work created the "paradigms for genetics in other organisms." The result of Thomas Hunt Morgan's work caused others to look at clusters of genetic traits, or characters, often inherited together. This is known as genetic linkage (6).

## DNA Mapping

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Gene mapping, aka DNA mapping began in 1911 with Edmund B. Wilson. He proved his theory that the gene for colorblindness was on the X chromosone because of its distinctive pattern of inheritance. Fathers do not pass it on to sons, and women rarely are colorblind. He discovered that the X chromosome was distinguishable by its size; females have two copies and males only one (7). According to Robert Cook-Deegan, for fifty years, study of the inheritance patterns of X-linked disease remained the most reliable gene mapping method. The first gene mapping of a human disease trait on another chromosome was published until 1968 (8).

**How does gene mapping occur?**

DNA should be thought of as two intertwined chains, which form a ladder. The ladders are made up of four rungs, or nucleotides bases. The four nucleotide bases are adenine (A), guanine (G), cystosine (C), and thymine (T). The bases form a four-letter-code that yields our genetic information. Each nucleotide base has a complimentary base. A pairs only with T, and G pairs only with C. In 1977, two ways for deciphering the DNA code were developed. Fredrick Sanger method is the most popular. First the strands of DNA are "unzipped," yielding two single strands of nucleotides. One single strand is chosen as the template and is replicated. A little piece of known code is tacked on to each on the strands of DNA. The template strands are separated into four groups so each can be subjected to slightly different reaction (9).

## Ethical Issues

There are many ethical issues that are raised as a direct result of our knowledge, understanding and usage of genome technology. First and foremost for me is what will be done with this information? Who has a right to have it? Should potential employers be given this information? Should insurance carriers be given this information? Will this technology absolve some and indict others of their responsibilities to society, family, government? Since this society, based on historical documentation, can't/won't free itself from the deleterious clutches of the "isms" (racism, sexism, ageism, genderism), would such information merely serve as another discriminating mechanism to ostracize individuals from mainstream society?

**Treatment and Medicine**

Genaissance Pharmaceticals, Inc. located in New Haven announced they have detected an "astonishing" variance at the genetic level in 82 unrelated people from four racial backgrounds- white, black, Asian, Hispanic. Their study of 313 genes, out of 30,000 identified by human genome scientists found that for each gene, there were on average 14 versions that could be inherited by a given person from parents. Gearld Vovis, Genaissance chief technology officer and senior vice president felt this might explain why there is such a wide variance in how people respond to medication. Vovis foresees a day when doctors will take a sample of blood, do a total genetic examination, and have that guide in prescribing treatment. The downside is that some unscrupulous individual having access to that information could misuse or exploit that individual (10). Another upside to this technology is that side effects produced by the ingestion of medication could be minimized or eradicated altogether.

**Insurance Companies**

If life insurance companies had this information, how might that impact society? Anyone who has ever sought life insurance is familiar with the little indicators that can prohibit your ability to become insured, or cause you to pay abhorrently elevated fees.

Smoking, obesity, cancer, AIDS, and a host of other malaise can increases your rates. The only up side to the current system is, if you have something you don't know about, it cannot be used against you. Now imagine if insurance companies had access to your genetic composition? You could potentially be penalized now for what may be coming twenty years (or never) down the road.

**Employment**

What if potential employers had this information? When you currently apply for a job, your "employability" is based on skill, experience, references, education and sometimes who-you-know. With access to your genetic code, any predisposition to alcoholism, cancer, Multiple Sclerosis, coronary heart disease, Huntington's disease, could become grounds for not being hired. Would it be ethical for the employer to deny you the opportunity to make money today, based on something that might not take place in the next five to ten years? From the potential employer's perspective, the answer would probably be a resounding yes. That will not set well with a potential employee who will need to be self-supporting.

**Taxpayers**

What will the potential cost be to the taxpayers? If more people are denied work based on their predisposition

to a given debilitating illness, would that add to the social-security disability roster? What will this information do for HMO's? Will their cost become even more prohibiting for more individuals and families? How will our social service agencies withstand the potential rise in homelessness and/or addictions?

## Moral Issues

Science and religion have been at odds for eons. The fundamental difference between the two is buttressed in philosophy. Science relies on empirical data. Science believes in the tangible and concrete. Religion is predicated on all faith. Faith is a belief in that which is not seen, or experienced. Religion says I believe therefore it is real. Science says reality must be grounded in fact. Religion sets its sights on a reality that has no bases in logic, but rather emotional rectitude.

When Charles Robert Darwin first presented his book of theories entitled, "On the Origin of Species by Means of Natural Selection in 1859, it was met fairly much as it is today. Darwin believed that first man evolved. Changes came about because of natural selection. Religion has promoted the notion that an omnipotent, omnipresent, and omniscient deity created all life here on Earth.

Today, the naturalist feel that Darwin has be vindicated. The human genome project confirms the theory on evolution.

> ...none of these headlines capture the most basic, the most important consequence of mapping out all of our genes. The genome reveals, indisputably and beyond any serious doubt, that Darwin was right mankind evolved over a long period of time from primitive animal ancestors. Our genes show that scientific creationism cannot be true. The response to all those who thump their bible and say there is no proof, no test and no evidence in support of evolution is, "The proof is right here, in our genes." Eric Lander of the Whitehead Institute in Cambridge, Mass., said that if you look at our genome it is clear that "evolution ...must make new genes from old parts."
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> The core recipe of humanity carries clumps of genes that show we are descended from bacteria. There is no other way to explain the jerry-rigged nature of the genes that control key aspects of our development. No one can look at how the book of life is written and not come away fully understanding that our genetic instructions have evolved from the same programs that guided the development of earlier animals. Our genetic instructions have been slowly assembled from the genetic instructions that made jellyfish, dinosaurs, wooly mammoths and our primate ancestors. There is, as the scientists who cracked the genome all agreed, no other possible explanation. Sure the business side of cracking our genetic code is fascinating. And we all need to be sure that our government does not leave us in the genetic lurch without laws to ensure our privacy and protect us against genetic discrimination (11).

The debate further intensifies as religion frowns on the notion that man will attempt to play God. Even those not particularly religious, fear a resurgence of Adolph Hitler's vision of creating the perfect race. Gene mapping will make it possible to do away with perceived flaws, or defects in children. Change the eye coloring, change the hair texture, add to the aptitude of the child, and by all means, let's make the child athletic and very aesthetically pleasing. Though we have the technology, is it moral to take away the variety that nature provides? Will scientists one day perceive certain ethnic groups as being unwanted flaws?

## Conclusion

There is no doubt that the human genome project started in 1990 left humankind hanging at the precipice of eminent power and direction. The collaboration of the U.S. Department of Energy and the National Institutes of Health seems to have been a good merger. Clearly the genie is out of the bottle and there is no way of stopping its progress. The potential for eliminating illnesses with debilitating effects on adults and children are clearly a good reason to continue. The public at-large must indeed become more knowledgeable so that an eye can be kept on Big Brother.

During the last twenty years, we have seen a thirty-percent increase in the number of centenarians. Clearly our bio-technical advances are working. We are spawning new scientific fields of study like "proteomics," the study of the production of proteins (12). We are correcting past wrongs, freeing those who have been incarcerated unjustly, thanks to our continuing breakthroughs with DNA. We have sequenced 3.1 billon letters of DNA, and proven that humans are made up of 30,000 to 40,000 genes, only two times more than fruit flies (13). Historical denials, like the Thomas Jefferson debauchery, once vehemently denied, now pierces the veneer of American piety; courtesy of the genome factor by proving he fathered several of Sally Hemings' children.

As more and more companies enter the arena, will there be a way to control what goes on? Will the quality and validity be retained, as more for-profit businesses like Celera Genomics enter the picture (14). Only time will tell. One salient thought keeps me from totally embracing this new technology: can we fallible creatures objectively and responsibly handle this knowledge?

## Lesson I: Ethics vs. Morals

Objective: To give students a clear understanding of the what morals and ethics entail

Materials: The American Heritage Dictionary

Ethic- 1. A principle of right or good conduct, or a body of such principles
2. A system of moral principles or values

Moral- 1. Of or concerned with the discernment or instruction of what is good and Evil.
2. Being or acting in accordance with established standards of good behavior

*Some questions for discussions:*

Go over the above words and definitions. Talk about the terms with the students

Define "good?" Define "evil?"

Where do those concepts come from in our society?

Who or what establishes those for a society?

Should there be a uniform standard for what constitutes good and evil?

Ethics is the "gray" area. Students need to understand what the term "gray" means

Use the scenario of a sales person giving you $3.50 too much change back. Do you keep it or give it back to the sales person. Have the students discuss what they would do in a similar situation. Discuss whether the actions of people are moral or ethical

Another example to use with students, to get across the concept of moral vs. ethical is to use the abortion debate

Be certain to give students time to exchange ideas, and then discuss the pros and cons of each.

Use paper charts so that information can be reviewed later.

This activity can work as a large or small group activity. Do not allow students to take the indecisive route. They must choose either or.

This unit must be taught as an interactive unit. Students must offer support for their answers and/or conclusions.

## Lesson II: Examining universal themes through scientific discovery

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Objective: to help students understand that science and life are intertwined

Material: MSNBC article entitled: "Darwin vindicated!" Cracking of human genome confirms theory of evolution.

Give students a list of the Universal Themes/Human Dilemmas written below

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|---|---|
| Good and Evil | Kindness and Hate |
| Life and Death | Joy and Sorrow |
| Love and Indifference | Perseverance and Surrender |
| Confrontation and Compromise | Loss and Gain |
| Forthrightness and Dishonesty | Honor and Treachery |
| Generosity and Greed | Belonging and Alienation |

Explain to the class that most of what befalls us in life, is centered on certain universal themes/ human dilemmas. Go over each one with the students. They should write each one down and as the teacher takes the class through them, take notes.

Give the students the article: "Darwin vindicated!" Cracking of human genome confirms theory of evolution.

Students are to be broken up into groups no larger than four. Each group reads the article, then decides (as a group) which universal themes are covered in the article "Darwin vindicated!" Cracking of human genome

confirms theory of evolution.

When the larger group reassembles, each team will make a presentation. Each group must be prepared to support their findings.

## Lesson III: Preparing and defending a point of view

Objective: to adopt a position and defended it ethically, morally, politically, and socially in a written essay

Material: Article- Cloned mice show abnormalities Concerns raised on critters created with embryonic stem cells MSNBC NEWS SERVICES July 5, 2001 website: wysiwyg://0/http:www.msnbc.com/news/596691.asp

At the beginning of the lesson go over the following terms with your students

a. ethically, b. morally, c. politically, and d. socially

Give each student a copy of the article: Cloned mice show abnormalities Concerns raised on critters created with embryonic stem cells. This can be read aloud, selecting different students, or each student may read the article silently to him/her self.

Write this on the blackboard, or on a chart:

Your task:

In class, we have discussed at length the notion that technology is raising a lot of issues ethically, morally, politically, and socially. Now that you have read this article, write an essay "showing" your readers how these issues are being raised through this article. Start with a good introduction and establish each of the areas mentioned above (ethically, morally, politically, and socially) in different paragraphs. Culminate your paper with a summary that reflects which human dilemmas this article demonstrates.

## Major Events in the U.S. Human Genome Project and Related Projects

(16. The U.S. Human Genome Project)

1983 LANL and LLNL begin production of DNA clone (cosmid) libraries representing single chromosomes.

1984 DOE OHER and ICPEMC cosponsor Alta, Utah, conference highlighting the growing role of recombinant DNA technologies. OTA incorporates Alta proceedings into report acknowledging value of human genome reference sequence.

1985 Robert Sinsheimer holds meeting on human genome sequencing at University of California, Santa Cruz. At OHER, Charles DeLisi and David A. Smith commission the first Santa Fe conference to assess the feasibility of a Human Genome Initiative.

1986 Following the Santa Fe conference, DOE OHER announces Human Genome Initiative. With $5.3 million, pilot projects begin at DOE national laboratories to develop critical resources and technologies.

1987 Congressionally chartered DOE advisory committee, HERAC, recommends a 15-year, multidisciplinary, scientific, and technological undertaking to map and sequence the human genome. DOE designates multidisciplinary human genome centers. NIH NIGMS begins funding of genome projects

1988 Reports by congressional OTA and NAS NRC committees recommend concerted genome research program. HUGO founded by scientists to coordinate efforts internationally. First annual Cold Spring Harbor Laboratory meeting on human genome mapping and sequencing. DOE and NIH sign MOU outlining plans for cooperation on genome research. Telomere (chromosome end) sequence having implications for aging and cancer research is identified at LANL.

1989 DNA STSs recommended to correlate diverse types of DNA clones.

DOE and NIH establish Joint ELSI Working Group.

1990 DOE and NIH present joint 5-year U.S. HGP plan to Congress. The 15-year project formally begins. Projects begun to mark gene sites on chromosome maps as sites of mRNA expression. Research and development begun for efficient production of more stable, large-insert BACs

1991 Human chromosome mapping data repository, GDB, established.

1992 Low-resolution genetic linkage map of entire human genome published.

Guidelines for data release and resource sharing announced by DOE and NIH.

1993 International IMAGE Consortium established to coordinate efficient mapping and sequencing of gene-representing cDNAs. The Scientist 13[4]:17, Feb. 15, 1999 Hot Papers In Genomics: G. Lennon, C. Auffray, M. Polymeropoulos, M.B. Soares, *The I.M.A.G.E. Consortium: An Integrated Molecular Analysis of Genomes and Their Expression* , Genomics, 33:1512, 1996. (Cited in more than 290 papers since publication) DOE-NIH ELSI Working Group's Task Force on Genetic and Insurance Information releases recommendations. DOE and NIH revise 5- year goals [Science 262, 43-46 (Oct. 1, 1993)]. French Généthon provides mega -YACs to the genome community. IOM releases U.S. HGP-funded report, *Assessing Genetic Risks* . LBNL implements novel transposon-mediated chromosome-sequencing system. GRAIL sequence-interpretation service provides Internet access at ORNL.

1994 Genetic-mapping 5-year goal achieved 1 year ahead of schedule.

Completion of second-generation DNA clone libraries representing each human chromosome by LLNL and LBNL. Genetic Privacy Act, first U.S. HGP legislative product, proposed to regulate collection, analysis, storage, and use of DNA samples and genetic information obtained from them; endorsed by ELSI Working Group. DOE MGP launched; spin-off of HGP. LLNL chromosome paints commercialized. SBH technologies from ANL commercialized. DOE HGP Information Web site activated for public and researchers.

1995 LANL and LLNL announce high-resolution physical maps of chromosome 16 and chromosome 19, respectively. Moderate-resolution maps of chromosomes 3, 11, 12, and 22 maps published. Physical map with over 15,000 STS markers published. First (nonviral) whole genome sequenced (for the bacterium Haemophilus influenzae). Sequence of smallest bacterium, Mycoplasma genitalium, completed; provides a model of the

minimum number of genes needed for independent existence. EEOC guidelines extend ADA employment protection to cover discrimination based on genetic information related to illness, disease, or other conditions.

1996 Methanococcus jannaschii genome sequenced; confirms existence of third major branch of life on earth. DOE initiates 6 pilot projects on BAC end sequencing Health Care Portability.and Accountability Act prohibits use of genetic information in certain health insurance eligibility decisions, requires DHHS to enforce health-information privacy provisions. HGP Participants Agreen on Sequencing Data Release Policies Bermuda Conference I DOE and NCHGR issue guidelines on use of human subjects for large-scale sequencing projects. Saccharomyces cerevisiae (yeast) genome sequence completed by international consortium. Sequence of the human T-cell receptor region completed. Wellcome Trust sponsors large-scale sequencing strategy meeting for international coordination of human genome sequencing.

1997 NIH NCHGR becomes National Human Genome Research Institute (NHGRI).

Escherichia coli genome sequence completed. Second large-scale sequencing strategy meeting held in Bermuda. (see also summary) High-resolution physical maps of chromosomes X and 7 completed. DOE-NIH Task Force on Genetic Testing releases final report and recommendations. DOE forms Joint Genome Institute for implementing high-throughput activities at DOE human genome centers, initially in sequencing and functional genomics. UNESCO adopts Universal Declaration on the Human Genome and Human Rights

1998 Hospital for Sick Children, Toronto, Ontario, to continue GDB data collection, curation. Caenorhabditis elegans genome sequence completed. DOE and NIH reveal new five-year plan for HGP, predict project completion by 2003. JGI exceeds sequencing goal, achieves 20 Mb for FY 1998. GeneMap'98 containing 30,000 markers released.

Incyte Pharmaceuticals announces plans to sequence human genome in 2 years.

Mycobacterium tuberculosis bacterium sequenced. Celera Genomics formed to sequence much of human genome in 3 years using HGP-generated resources. DOE funds production BAC end sequencing projects Largest-ever ELSI meeting attended by over 800 from diverse disciplines and sponsored by DOE; Whitehead Institute; and the American Society of Law, Medicine, and Ethics. Human Genome Project passes midpoint.

1999 First Human Chromosome Completely Sequenced! On December 1, researchers in the Human Genome Project announced the complete sequencing of the DNA making up human chromosome 22. Joint Genome Institute sequencing facility opens in Walnut Creek, CA. Major Drug Firms Create Public SNP Consortium

The Billion Base Pair Celebration November 23, 1999. Bruce Alberts, President, National Academy of Sciences and early planner of the Genome Project; Francis Collins, Director, NHGRI; Secretary of HHS, Donna Shalala; Secretary of DOE, Bill Richardson. (Total Running Time: 01:09:45; Bandwidth: 146 Kbps)

HGP advances goal for obtaining a draft sequence of the entire human genome from 2001 to 2000.

2000 HGP leaders and President Clinton announce the completion of a "working draft"

DNA sequence of the human genome. White House Press Conference: The Human Genome Project, June 26, 2000 (Total Running Time: 00:41:23; Bandwidth: 33 Kbps)

Press briefing and remarks An Interview with Ari Patrinos, Director U.S. DOE Human Genome Program Part One: Reaction to President Clinton's Announcement of the Completion of a Draft Sequence of the Human

Genome Part Two: Origins of the Human Genome Project, NIH Collaboration, and the Private Sector Role Part Three: Application of Genome Discoveries, Next Steps in the Human Genome Project, and Ethical Considerations International research consortium publishes chromosome 21 genome, the smallest human chromosome and the fifth to be completed. DOE researchers announce completion of chromosomes 5, 16, and 19 draft sequence. International collaborators publish genome of fruit fly Drosophila melanogaster, the largest organism sequenced to date. President Clinton signs executive order prohibiting federal departments and agencies from using genetic information in hiring or promoting workers.

**Acronyms (17. The U.S. Human Genome Project)**

ADA - Americans with Disabilities Act

ANL - Argonne National Laboratory, a Department of Energy Laboratory

BAC - bacterial artificial chromosome

cDNA - complementary deoxyribonucleic acid

DHHS - Department of Health and Human Services at National Institutes of Health (NIH)

DNA - deoxyribonucleic acid

DOE - Department of Energy

EEOC - Equal Employment Opportunity Commission

ELSI - ethical, legal, and social issues

FY - federal fiscal year (October 1 to September 30)

GDB - Genome Database

GRAIL - Gene Recognition and Analysis Internet Link

HERAC - Health and Environmental Research Advisory Committee

HGI - Human Genome Initiative

HGP - Human Genome Project, Human Genome Program

HUGO - Human Genome Organization

ICPEMC - International Commission for Protection Against Environmental Mutagens and Carcinogens

IMAGE - Integrated Molecular Analysis of Gene Expression

IOM - Institute of Medicine

JGI - the Department of Energy's Joint Genome Institute in Walnut Creek, California. The JGI houses the DOE's production sequencing facility.

LANL - Los Alamos National Laboratory, a Department of Energy Laboratory

LBNL - Lawrence Berkeley National Laboratory, a Department of Energy Laboratory

LLNL - Lawrence Livermore National Laboratory, a Department of Energy Laboratory

MGP - Microbial Genome Project

MOU - memorandum of understanding

mRNA - messenger ribonucleic acid

NAS - National Academy of Sciences

NCHGR - National Center for Human Genome Research at National Institutes of Health (NIH)

NHGRI - National Human Genome Research Institute at National Institutes of Health (NIH)

NIGMS - National Institute of General Medical Sciences at National Institutes of Health (NIH)

NIH - National Institutes of Health

NRC - National Research Council

OBER - Office of Biological and Environmental Research, U.S. Department of Energy (formerly Office of Health and Environmental Research)

OHER - Office of Health and Environmental Research, U.S. Department of Energy (now Office of Biological and Environmental Research)

ORNL - Oak Ridge National Laboratory, a Department of Energy Laboratory

OTA - Office of Technology Assessment

R&D - research and development

SBH - Sequencing by hybridization

STS - sequence tagged site

UNESCO - United Nations Educational, Scientific, and Cultural Organization

YAC - yeast artificial chromosome

## notes

1. www.dictionary.com

2. World Book, pp.85-87, *World Book Encyclopedia* , United States, 1998

3. The U.S. Human Genome Project, The Introduction. http://www.ornl.gov/hgmis/project/5yrplan/intro.html

4. Cook-Deegan, Robert, *The Gene War* . New York: W.W.Norton Company. pp. 29-33. 1994.

5. Ibid

6. Ibid

7. Ibid

8. Ibid

9. MSNBC, Genome bacteria theory debugged http://www.msnbc.com/news/590130.asp Thursday, June 21, 2001

10. MSNBC Reuter, Huge gene Variation found in Humans: Find May Explain Differing Responses to Medication, http://www.msnbc.com/news, July 12, 2001

11. Caplan, Arthur, 'Darwin vindicated!' Cracking of human genome confirms theory of evolution, MSNBC, February 21, 2001

12. MSNBC/Staff Reporters, Human genome published, ushers in new age in medicine:Feat will revolutionize diagnosis, treatment of disease, http://www.msnbc.com/news, February 12, 2001.

13. Ibid

14. Associated Press, *Drop of Blood Reveals Family history: quick needle prick, gene testing offer clue* , March 5, 2001.

15. Associated Press, Celera keeping mouse map to itself Rodent genome available only to paying customers, April 27, 2001.

16. The U.S. Human Genome Project http://www.ornl.gov/hgmis/project/5yrplan/intro.html

17. Ibid

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Associated Press, *Drop of Blood Reveals Family history: quick needle prick, gene testing offer clue* , March 5, 2001. With the advances in gene identification, tracing one's ancestry will become that much easier. This article also elaborates on a couple of historical verifications this technology has rendered.

Associated Press, *Celera keeping mouse map to itself Rodent genome available only to paying customers* , April 27, 2001. Clearly not

all advances in the genome world are for altruistic purposes. Celera Genomics decided to forgo publishing its scientific discoveries in a scientific journal, and is instead making their complete mouse genome available for a price.

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Bodmer, Walter and Mckie, Robin, *The Book of Man* . New York: Scribner. 1994. Details the history of the genetic code. Gives insight as to how we are and will use these human codes.

Callahan, Daniel, *What Kind of Life* . New York: Simon and Shchuster. 1990. This book deals with the many philosophical and ethical issues that our society will have to recon with as we continue to make greater technological and scientific advances.

Caplan, Arthur, '*Darwin vindicated!*' *Cracking of human genome confirms theory of evolution* , MSNBC, February 21, 2001 Article that talks about the genome project as garnering irrefutable evidence to support the ascertain that humans evolved over a long period of time.

Cook-Deegan, Robert, *The Gene War* . New York: W.W.Norton Company. 1994. Armed with facts and figures, the author eloquently forces his readers to consider the costs financially, politically, and socially. This book also contains a rather extensive reference section in the back, enabling its readers to probe deeply as they choose into the controversies inherent in the biotechnology debate.

Hamilton, Michael P. *The Genetics and the Future of Man* . Grand Rapids, Michigan: William B. Eerdmans Publishing Company. 1972. An interesting book with a multiplicity of individuals from various fields (biology, law, research, chemistry, theology) sharing their expertise on various topics germane to the genome debate.

Kitcher, Philip, *Abusing Science: The Case Against Creationism* . Cambridge, Massachusetts: The MIT Press. 1982. Philip Kitcher does an excellent job of framing the fundamental argument between Creationism (religious fundamentalists) and Evolutionism (scientists). This book is useful in helping students understand how these two fractions are still in many respects framing the arguments today relative to the Genome Project.

MSNBC/Reuters, *Huge gene Variation found in Humans: Find May Explain Differing Responses to Medication* , http://www.msnbc.com/news, July 12, 2001. This web page has an interactive video attached which explains how gene mapping is done.

MSNBC/Reuters, Genome bacteria theory debugged: *Humans did not pick up genes from organisms* . http://www.msnbc.com/news, June 20, 2001. This article seeks to shed some debunking data for the argument that infectious bacteria or genetically modified organisms transferred genes to humans.

MSNBC/Staff Reporters, *Human genome published, ushers in new age in medicine: Feat will revolutionize diagnosis, treatment of disease* , http://www.msnbc.com/news, February 12, 2001. Released at the time the announcement was made of the sequencing of 3.1 billion letters of DNA. This article seeks to provide a prognosis for its usuage.

MSNBC/Associated Press/Reuters, *Gene defect linked to pre-eclampsia* , http://www.msnbc.com/news, April 2, 2001, London. Dutch scientists have discovered a defective gene is responsible for pre-eclampsia. This defect accounts for 10 percent of maternal deaths in pregnancy.

Stableford, Brian, *Future Man: Brave new world or Genetic Nightmare?* New York: Crown Publishers, Inc. 2001. Here is a comprehensive look at all of our current biotechnology, merging together under one cover. This book deals with a multiplicity of subjects ranging from evolution, gene mapping, organ transplants, reattaching limbs, and aging. This book propels one further into the future by prognosticating what future technological advances will do to the inhabitants on planet earth.

The U.S. Human Genome Project, http://www.ornl.gov/hgmis/project/5yrplan/intro.html This website is set up by the United States government. It is a great reference source because it indexes many aspects of the Genome project. It is update frequently

Veatch, Robert M. *Death, Dying and the Biological Revolution* . New Haven, Connecticut: Yale University Press. 1989. Now that we have the ability to prolong life, what ethical and moral dilemmas will we face as a society? This book raises questions, which will segue into discussions about the possibilities. This book covers a bevy of issues arising out of our technology allowing people to live longer.

World Book, vol. 8, pp.85-87, *World Book Encyclopedia* , United States, 1998. A good initial overview of genetic engineering for students.