Name ____ Period _________ Date ________________

Human Genome Project Reading

1. Using a highlighter (or by underlining in pen), select sentences and phrases that you think are important in this reading. What I want you to get from this reading is how the results of the Human Genome Project (HGP) are expected to positively impact various scientific fields.

2. What are three current and potential applications of the Human Genome Project (HGP)?

3. Name a couple of genetic disorders whose research has benefited from the HGP?

4. What are three ways that the HGP is expected to benefit each of the following sectors:

   Energy and the Environment

   Bioarchaeology

   DNA Forensics

   Agriculture

Potential Benefits of Human Genome Project Research

Rapid progress in genome science and a glimpse into its potential applications have spurred observers to predict that biology will be the foremost science of the 21st century. Technology and resources generated by the Human Genome Project and other genomics research are already having a major impact on research across the life sciences. The potential for commercial development of genomics research presents U.S. industry with a wealth of opportunities, and sales of DNA-based products and technologies in the biotechnology industry are projected to exceed $45 billion by 2009 (Consulting Resources Corporation *Newsletter*, Spring 1999).

Some current and potential applications of genome research include

- Molecular medicine
- Energy sources and environmental applications
- Risk assessment
- Bioarchaeology, anthropology, evolution, and human migration
- DNA forensics (identification)

Agriculture, livestock breeding, and bioprocessing

Molecular Medicine

- *Improved diagnosis of disease*
- *Earlier detection of genetic predispositions to disease*
- *Rational drug design*
- *Gene therapy and control systems for drugs*
- *Pharmacogenomics "custom drugs"*

Technology and resources promoted by the Human Genome Project are starting to have profound impacts on biomedical research and promise to revolutionize the wider spectrum of biological research and clinical medicine. Increasingly detailed genome maps have aided researchers seeking genes associated with dozens of genetic conditions, including myotonic dystrophy, fragile X syndrome, neurofibromatosis types 1 and 2, inherited colon cancer, Alzheimer's disease, and familial breast cancer.

On the horizon is a new era of molecular medicine characterized less by treating symptoms and more by looking to the most fundamental causes of disease. Rapid and more specific diagnostic tests will make possible earlier treatment of countless maladies. Medical researchers also will be able to devise novel therapeutic regimens based on new classes of drugs, immunotherapy techniques, avoidance of environmental conditions that may trigger disease, and possible augmentation or even replacement of defective genes through gene therapy.

Energy and Environmental Applications

- *Use microbial genomics research to create new energy sources (biofuels)*
- *Use microbial genomics research to develop environmental monitoring techniques to detect pollutants*
- *Use microbial genomics research for safe, efficient environmental remediation*
- *Use microbial genomics research for carbon sequestration*

In 1994, taking advantage of new capabilities developed by the genome project, DOE initiated the Microbial Genome Program to sequence the genomes of bacteria useful in energy production, environmental remediation, toxic waste reduction, and industrial processing. A follow-on program, Genomic Science Program (GSP) builds on data and resources from the Human Genome Project, the Microbial Genome Program, and systems biology. GSP will accelerate understanding of dynamic living systems for solutions to DOE mission challenges in energy and the environment.
Despite our reliance on the inhabitants of the microbial world, we know little of their number or their nature: estimates are that less than 0.01% of all microbes have been cultivated and characterized. Microbial genome sequencing will help lay a foundation for knowledge that will ultimately benefit human health and the environment. The economy will benefit from further industrial applications of microbial capabilities.

Information gleaned from the characterization of complete microbial genomes will lead to insights into the development of such new energy-related biotechnologies as photosynthetic systems, microbial systems that function in extreme environments, and organisms that can metabolize readily available renewable resources and waste material with equal facility. Expected benefits also include development of diverse new products, processes, and test methods that will open the door to a cleaner environment. Biomanufacturing will use nontoxic chemicals and enzymes to reduce the cost and improve the efficiency of industrial processes. Microbial enzymes have been used to bleach paper pulp, stone wash denim, remove lipstick from glassware, break down starch in brewing, and coagulate milk protein for cheese production. In the health arena, microbial sequences may help researchers find new human genes and shed light on the disease-producing properties of pathogens.

Microbial genomics will also help pharmaceutical researchers gain a better understanding of how pathogenic microbes cause disease. Sequencing these microbes will help reveal vulnerabilities and identify new drug targets.

Gaining a deeper understanding of the microbial world also will provide insights into the strategies and limits of life on this planet. Data generated in this young program have helped scientists identify the minimum number of genes necessary for life and confirm the existence of a third major kingdom of life. Additionally, the new genetic techniques now allow us to establish more precisely the diversity of microorganisms and identify those critical to maintaining or restoring the function and integrity of large and small ecosystems; this knowledge also can be useful in monitoring and predicting environmental change. Finally, studies on microbial communities provide models for understanding biological interactions and evolutionary history.

Risk Assessment

- *Assess health damage and risks caused by radiation exposure, including low-dose exposures*
- *Assess health damage and risks caused by exposure to mutagenic chemicals and cancer-causing toxins*
- *Reduce the likelihood of heritable mutations*

Understanding the human genome will have an enormous impact on the ability to assess risks posed to individuals by exposure to toxic agents. Scientists know that genetic differences make some people more susceptible and others more resistant to such agents. Far more work must be done to determine the genetic basis of such variability. This knowledge will directly address DOE's long-term mission to understand the effects of low-level exposures to radiation and other energy-related agents, especially in terms of cancer risk.

Bioarchaeology, Anthropology, Evolution, and Human Migration

- *Study evolution through germline mutations in lineages*
- *Study migration of different population groups based on female genetic inheritance*
- *Study mutations on the Y chromosome to trace lineage and migration of males*
- *Compare breakpoints in the evolution of mutations with ages of populations and historical events*

Understanding genomics will help us understand human evolution and the common biology we share with all of life. Comparative genomics between humans and other organisms such as mice already has led to similar genes associated with diseases and traits. Further comparative studies will help determine the yet-unknown function of thousands of other genes.

Comparing the DNA sequences of entire genomes of different microbes will provide new insights about relationships among the three kingdoms of life: archaebacteria, eukaryotes, and prokaryotes.

DNA Forensics (Identification)

- *Identify potential suspects whose DNA may match evidence left at crime scenes*
- *Exonerate persons wrongly accused of crimes*
- *Identify crime and catastrophe victims*
- *Establish paternity and other family relationships*
- *Identify endangered and protected species as an aid to wildlife officials (could be used for prosecuting poachers)*
- *Detect bacteria and other organisms that may pollute air, water, soil, and food*
- *Match organ donors with recipients in transplant programs*
- *Determine pedigree for seed or livestock breeds*
- *Authenticate consumables such as caviar and wine*

Any type of organism can be identified by examination of DNA sequences unique to that species. Identifying individuals is less precise, although when DNA sequencing technologies progress further, direct characterization of very large DNA segments, and possibly even whole genomes, will become feasible and practical and will allow precise individual identification.

To identify individuals, forensic scientists scan about 10 DNA regions that vary from person to person and use the data to create a DNA profile of that individual (sometimes called a DNA fingerprint). There is an extremely small chance that another person has the same DNA profile for a particular set of regions.

Agriculture, Livestock Breeding, and Bioprocessing

- *Disease-, insect-, and drought-resistant crops*
- *Healthier, more productive, disease-resistant farm animals*
- *More nutritious produce*
- *Biopesticides*
- *Edible vaccines incorporated into food products*
- *New environmental cleanup uses for plants like tobacco*

Understanding plant and animal genomes will allow us to create stronger, more disease-resistant plants and animals --reducing the costs of agriculture and providing consumers with more nutritious, pesticide-free foods. Already growers are using bioengineered seeds to grow insect- and drought-resistant crops that require little or no pesticide. Farmers have been able to increase outputs and reduce waste because their crops and herds are healthier.

Alternate uses for crops such as tobacco have been found. One researcher has genetically engineered tobacco plants in his laboratory to produce a bacterial enzyme that breaks down explosives such as TNT and dinitroglycerin. Waste that would take centuries to break down in the soil can be cleaned up by simply growing these special plants in the polluted area.