UNIT 3: BIOLOGY

BOOK 3: GENETIC MODIFICATION

NAME: ________________  BLOCK: ______
Lesson 1.8 – Modern Genetic Technology

Genetic Technology

☐ Technologies that allow us to ________________, ________________, or ________________ the structure of DNA molecules are called ________________

☐ During your lifetime, these technologies have become ________________ and ________________ than ever before

☐ In March of _______, an international collaboration announced that it had created the ________________, ________________, living yeast cells, that were built by ________________

A Technology Example: Genomes

☐ Determining the base pair sequence of ________________ is known as ________________

☐ The first organism to have its genome sequenced was a ________________, we now know the genomes of many other organisms, including insects, plants, birds, mammals, and disease-causing viruses

☐ The first human genome took ________________, cost ________________, and required ________________: now it takes about ________________, costs less than ________________, and requires a ________________ to set up the machine

Cost of Sequencing the Human Genome

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>$95,263,072</td>
</tr>
<tr>
<td>2002</td>
<td>$61,448,422</td>
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<tr>
<td>2003</td>
<td>$40,157,554</td>
</tr>
<tr>
<td>2004</td>
<td>$19,519,312</td>
</tr>
<tr>
<td>2005</td>
<td>$13,801,724</td>
</tr>
<tr>
<td>2006</td>
<td>$10,474,556</td>
</tr>
<tr>
<td>2007</td>
<td>$7,147,571</td>
</tr>
<tr>
<td>2008</td>
<td>$343,502,333</td>
</tr>
<tr>
<td>2009</td>
<td>$29,092,197</td>
</tr>
<tr>
<td>2010</td>
<td>$7,950,000</td>
</tr>
<tr>
<td>2011</td>
<td>$5,000,000</td>
</tr>
</tbody>
</table>

first synthetic organism: Saccharomyces yeast
Genetic Engineering

- The technologies that allow scientists to ____________________ of cells or organisms, either
  by ___________________________ or by ___________________________________
  ___________________________, are known as ___________________________

- Genetic engineering was first accomplished in ______ to
  _________________________________________

- Like other genetic technologies, this is now much easier than ever: a new technology called ________________ allows us to
  __________________________________________
  using a protein from bacteria

Genetically Modified Organisms

- Use of genetic engineering to modify the DNA of organisms creates ___________________________

- Crop plants are genetically modified to be
  ___________________________________________, to
  ___________________________________________ (especially
  herbicides), or to __________________________

- _____ of crops worldwide are genetically modified; in the US
  ______________ of the cotton, soybean, and corn crops are
  GMOs

Table 13-1  Genetically Engineered Crops with USDA Approval

<table>
<thead>
<tr>
<th>Genetically Engineered Trait</th>
<th>Potential Advantage</th>
<th>Examples of Bioengineered Crops Receiving USDA Approval Between 1992 and 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to herbicide</td>
<td>Application of herbicide kills weeds, but not crop plants, producing higher crop yields.</td>
<td>canola, corn, cotton, flax, potato, rice, soybean, tomato</td>
</tr>
<tr>
<td>Resistance to pests</td>
<td>Crop plants suffer less damage from insects, producing higher crop yields.</td>
<td>corn, cotton, potato, soybean</td>
</tr>
<tr>
<td>Resistance to disease</td>
<td>Plants are less prone to infection by viruses, bacteria, or fungi, producing higher crop yields.</td>
<td>papaya, potato, squash</td>
</tr>
<tr>
<td>Sterile</td>
<td>Transgenic plants cannot cross with wild varieties, making them safer for the environment and more economically productive for the seed companies that produce them.</td>
<td>chicory, corn</td>
</tr>
<tr>
<td>Altered oil content</td>
<td>Oils can be made healthier for human consumption or can be made similar to more expensive oils (such as palm or coconut).</td>
<td>canola, soybean</td>
</tr>
<tr>
<td>Altered ripening</td>
<td>Fruits can be more easily shipped with less damage, producing higher returns for the farmer.</td>
<td>tomato</td>
</tr>
</tbody>
</table>
What is genetic engineering?

Living things naturally create useful products. 

[Image of yeast]

For example, yeast naturally converts sugar into carbon dioxide and alcohol, and is used in baking and brewing.

Yeast can also be genetically engineered to produce vaccines for human diseases.

How does genetic engineering work?

Genetic engineering involves four main stages.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select the product or characteristic needed</td>
<td></td>
</tr>
<tr>
<td>2. Isolate genes from specialist cells</td>
<td></td>
</tr>
<tr>
<td>3. Insert the genes into target cells</td>
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<tr>
<td>4. Replicate the new organism</td>
<td></td>
</tr>
</tbody>
</table>

What is the product in this example? Hepatitis B vaccine.

GM crops

Crops can be given extra genes for new and useful characteristics. They are genetically modified (GM).

What characteristics might be useful in crops?

- __________
- __________
- __________
- __________
- __________
- __________
- __________

Pest-resistant crops

[Image of plants]

The gene for a powerful __________ is added to the potato plant.

If the beetle tries to eat the potato plant, it is killed by the toxin.

What benefits might this have for the environment?

Frost-resistant crops

Crops can be genetically modified so they are resistant to _____________________________.

For example, __________ could be genetically modified to be resistant to frost.

[Image of GM lettuce and non-GM lettuce]

Why are some people against the development and use of GM crops?

Plants with extra vitamins

[Image of rice]

Rice can be genetically modified to make ___________________________ a substance that is converted into vitamin A in the body.

The colour of the rice is an indication of how much more beta-carotene it contains.

The GM rice is called ____________ and is being developed to help fight vitamin A deficiency and blindness in developing countries.
Animals are modified to provide ________________, to produce ________________ or organ transplants, to be ________________________, or to improve their ________________

Other Applications of Genetic Technology

______________: creating organisms with ________________ ____________ (Dolly the sheep)

Manipulating embryonic stem cells to ________________ or ________________

______________: inserting _____________________ into humans born with ______________________

Protecting ______________ species or perhaps even restoring ____________ species

Sequencing of DNA in ________________, used to identify the people present at the crime scene

DNA ‘fingerprinting’ is a genetic technology used in forensics and criminology

DNA fingerprint is then compared to the suspects
Changing the genetic code

_________ are often genetically engineered to produce useful chemicals because their DNA is loose in the cytoplasm, making it easy to modify. They also grow _____________.

A new gene can be inserted into the ____________ and the bacteria then produce the protein that the gene codes for.

How can bacteria produce human insulin?

Stage 1

Stage 2

Stage 3

Stage 4

insulin-producing cell

insulin gene

enzymes

plasmid
Alternatives to bacteria

Genetically-engineered bacteria are unable to make proteins that are identical to those found naturally in humans, despite having human DNA.

This is because the way in which bacteria make proteins is different to the way that mammals make proteins.

A better way is to use genetically-engineered grown in industrial bioreactors. These produce proteins that are \_______\ to the ones found in humans.

Transgenic goats

For example, the gene for a human antibody can be introduced into goats.

Additional controlling DNA is also introduced, so the human antibody is only produced in the goat’s \_______\ at a certain time.

The antibody is then \_______\ the goat’s milk, where it can be purified and can used to treat diseases.

What is transgenics?

Foreign DNA, including DNA from humans, can be inserted into animals. This is called \_______\.

The protein encoded by the DNA can then be produced in a \_______\ of the transgenic animal at a specific time.

This method produces higher levels of antibody, more easily and cheaply, than by using genetically-engineered bacteria or mammalian cells.

What is gene therapy?

Children with faulty immune systems have been cured by adding genes to their bone marrow cells. This is called \_______\.

1. A ‘\_______\’ version of the faulty gene is cut from normal DNA and copied.
2. The gene is added to a \_______\.
3. The virus \_______\ into the patient’s cells, where the healthy gene is released.
4. The patient’s cells can then make the correct product of the gene. The patient is then cured.
Ethical Considerations

Incredible technological advances give us the ability to do things that we have never been able to do, but also present us with ethical and moral questions we have never had to answer, such as:

- Do ____ have the right to modify living organisms? Should we be able to __________ and patent GMO or synthetic organisms?
- Does the _________________ have the right to control technologies?
  How can we ensure that political opinions do not ___________________________________?
- Should we know _____________________? Should that information be shared _____________ for medical or scientific reasons?

What are the advantages and disadvantages of GM crops?
Part 1: Read the following article, taken from the Washington Post. Try to understand the gist of the article (not necessarily every single part of it), and think about your own opinions on the subject while reading.

FOR SALE IN ICELAND: A NATION'S GENETIC CODE

By John Schwartz

January 12, 1999

Iceland has decided to become the first country in the world to sell the rights to the entire population's genetic code to a biotechnology company -- a move that is highlighting the promise and risks of the genetic information age. The strikingly uniform DNA of Iceland's largely blue-eyed, blond-haired populace is expected to provide an invaluable resource for studying human genetics, leading to fundamental insights into many diseases, proponents say. "It really is a complete paradigm shift in medicine," said Jonathan Knowles, who heads research at Roche Holding AG, which has signed a $200 million, five-year deal to develop new drugs and tests from the data. But the plan is highly controversial because it will pool richly detailed genetic, medical and genealogical information about Iceland's 270,000 residents into a set of linked databases that companies will search for clues into the nature of disease. Although a majority of Iceland's citizens support the plan, a vocal minority of scientists and doctors -- with support from a worldwide network of like-minded privacy advocates -- have stoked the controversy. "Most doctors and scientists here in Iceland are in favor of the basic purpose of this project -- but find the proposed solution quite unethical and unrealistic," said Jon Erlendsson, a Reykjavik-based engineer and writer who believes the database network will eventually fail because doctors and patients will refuse to cooperate once its nature is better understood. Opponents fear the database could make the most private details of individuals' lives public. People with mental illness or other health problems could be stigmatized, perhaps suffering job discrimination. Patients may become less willing to divulge personal information to their doctors. And in a country where some estimates say that about 10 percent of the population may have been born out of wedlock, long-held family secrets could leak out. The fight in Iceland is focusing attention on the potential risks of efforts to mine and refine personal data -- efforts that are also increasingly common in the United States and around the world. "Turning the population into electronic guinea pigs" should serve as a warning to Americans, said David Banisar of the Washington-based Electronic Privacy Information Center. Despite the objections, Iceland could begin collecting blood to obtain the DNA samples within six months, after a period in which citizens may decline to participate. Precisely how the blood will be collected has not been determined. The plan was proposed by Kari Stefansson, a Harvard-educated Icelandic scientist, in part as a way to develop a new natural resource for a country where unemployment is a chronic problem. Iceland's parliament, the Althing, approved the plan last month, passing a law authorizing the database and creating the framework that will enable a local company, deCODE Genetics, to hold an unusual 12-year monopoly on data marketing rights. Iceland's population presents a tantalizing opportunity for
those who study genetics because all of that blond hair and blue eyes reflects one of the most remarkably homogeneous populations in the world. The original blend of 9th century Norse stock and Celtic seamen has been largely unchanged, and that gene pool was further restricted by bouts of plague, famine and volcanic eruption. This comparatively simple set of genes makes genetic prospecting far less daunting than attempting to track down faulty genes among the millions of chemical components arrayed along the human chromosomes in heterogeneous populations like that of the United States. (It’s a little like trying to detect a single flat note sung by one person while wandering through a public park in which everyone is singing his own favorite tune: The distractions of the merengue, the klezmer, the classical and the sea chanteys make it even harder to find the errant note. A homogeneous population such as Iceland’s, however, is more like a chorus, with most people singing from the same page -- so it’s much easier to discern when one of the singers is off.) Because Iceland has a strong health care system with extensive record-keeping, as well as genealogical records that go back hundreds of years, it offers tremendous potential for ferreting out the relationship between the genetic and environmental origins of disease, said Stefansson. Researchers will be able to sift through the data to uncover medical insights "in a systematic manner," Stefansson said, adding that "it’s going to be a great discovery tool." Those in Iceland supporting the plan say it strikes a careful balance between the rights of the citizenry and the needs of science. The unified health database will "improve delivery of health services. On balance, I think the potential advantages will outweigh the risks involved," said Solveig Petursdottir, a member of parliament who voted for it. Opponents of the law cite numerous problems. Many of them are among the nation’s leading scientists and scholars. They argue their case in Icelandic and English on their Web site, and have formed an advocacy group, Mannvernd, "to promote ethical standards in medical research, science and in the biotechnology industry in Iceland” and to oppose the new law, which the group’s Web site says "infringes upon accepted medical, scientific and commercial standards." They say that they understand the importance of deCODE’s work and support earlier efforts by the company to understand genetic diseases by studying the DNA of Icelandic volunteers. But the new plan, they say, takes away too much privacy -- for private gain -- and gives too little back to the nation and to science. “When you put genealogical information into the databank and also genetic data, then the databank knows more about you than you know about yourself,” said Tomas Zoega, chairman of the Icelandic Medical Association’s ethics council. "Some look at it as a fantastic idea. But I think the idea is a scary one." Opponents complain that they still have not been told how the DNA will be collected, or how much information will be stored in the database. Those details will be decided by a government-created committee. The company has promised to collect the data "anonymously" but uses that word with great nuance, opponents say. Among most database experts, "anonymous" almost always means that identifying information will be stripped away. But in this case, the information directly identifying individuals will be encrypted so that it cannot easily be read by unauthorized people. British researcher Ross Anderson has prepared a paper for the Icelandic Medical Association that questions the notion that anonymity can be protected when so much data is collected. The company has pledged to program the computers to produce no fewer than 10 records for any query so that the computers can never identify an individual. But multiple searches can winnow one name out of 10, Anderson said, adding that no encryption scheme can mask identities when so much personal information is stored in one place.
Opponents also argue that the pay-as-you-go research concept damages the spirit of science, in which knowledge should be freely shared. Most important from a doctor’s point of view, Zoega said, is the possibility that "trust between patients and physicians will diminish and maybe disappear" if people believe that every fact about them will be entered into the database. As for those who support it, "I think that those are the people who have not been ill, who do not have medical records lying about," said Petur Hauksson, a psychiatrist who chairs the Icelandic Psychiatric Patients Association. Opposition to the database law is, if anything, even stronger outside of Iceland. Privacy officials of the European Union have been sharply critical of the database proposal. Researchers with expertise in genetics and public policy said that the nation's scientific goal is laudable but that the plan is flawed. Simon Davies, head of the London-based Privacy International, said the trend toward the collection of more data at the expense of privacy is a worldwide problem. "A sensible civil libertarian will say the democratic process failed us. It's all just evaporated in the past five years." Davies said people are too quick to accede to arguments based on "economic rationalism" without thinking about the broader implications. "Thin-lipped accountants have taken control," he said. Iceland has gone further than other European nations, Davies said, but it will not be alone for long. "Wherever you see a bad law, you can bet that the rest of Europe will sink to that level and integrate." Pharmaceutical scientist Knowles acknowledged the potential for abuse. "We must do everything possible to ensure that privacy of individuals is maintained," he said. Because the data will be used to look for statistical relationships in large populations, the company has no motivation to examine information about specific persons, he said. "Individual data is of no use whatsoever." Fears of abuse should be addressed through legislation, not by restricting the project, Stefansson said. "We should not let the bad guys dictate" public policy, he said. "We're not going to let people die simply because it might be abused. "You do not place limitations on the creation of new knowledge," he said, "you place limitations on the ways that the new knowledge can be used."

**Part 2:** Answer the following questions in complete sentences.

1. Why did the government decide to add genetic information to its medical database?

2. Why were people concerned that a private company got the database contract?

3. Do you think any database is hacker-proof? Why or why not?
4. What makes Iceland an ideal place to study genetic diseases?

5. Do you think other nations should follow the Iceland example? Why or why not?

6. Research what happened to this genetic database. Is it still active today?

Part 3: Answer the following questions in complete sentences. These questions related to genetic information in general, not just the Icelandic database.

7. Who has the right to access and use our personal genetic information?

8. If there was a database of everybody’s genetic information, who should have the right to use the information?
**Biology Unit Review Package**

**Vocabulary**

Referring to your notes and textbook, define each of the following vocabulary terms in a complete sentence:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adaptation</td>
<td></td>
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<tr>
<td>2. Adaptive Radiation</td>
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<td>3. Allele</td>
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<td>4. Artificial Selection</td>
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<td>5. Carcinogen</td>
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<td>6. Chromosome</td>
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<td>7. Co-dominance</td>
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<td>8. Complementary Base Pairing</td>
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<td>9. Complete Dominance</td>
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<td>10. DNA</td>
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<td>11. Dominant</td>
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<td>12. Extinction</td>
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<td>13. Gene</td>
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<td>14. Genetic Engineering</td>
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<td>15. Incomplete Dominance</td>
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<td>16. Mendelian Genetics</td>
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<td>17. Mutagen</td>
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<td>18. Mutation</td>
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<td>19. Natural Selection</td>
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<td>20. Selection Pressure</td>
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<td>21. Protein</td>
<td></td>
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<td>22. Punnett Square</td>
<td></td>
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<tr>
<td>23. Recessive</td>
<td></td>
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<tr>
<td>24. Sex-Linked Inheritance</td>
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</tbody>
</table>
**Knowledge**

Answer each of the following questions in complete sentences. It should be clear from your answer what the question was!

1. Explain how the components of a DNA molecule join together to create the complete double helix structure.

2. Distinguish between genes and alleles.

3. Describe one of Mendel’s experiments on peas.
4. Explain the two ‘laws’ resulting from Mendel’s experiments.

5. Explain the difference between complete dominance, co-dominance, and incomplete dominance using your own fictional examples.

6. A single gene controls the hair texture of guinea pigs. The allele for straight hair (H) is completely dominant over the allele for curly hair (h). If a breeder was to cross two hybrid guinea pigs that had both alleles, what is the probability of their offspring having curly hair? Show all your work.
7. In snapdragons, flower color is controlled by incomplete dominance. The two alleles are red (R) and white (W). The hybrid trait (RW) is expressed as pink flowers. If a plant breeder was to cross a white plant with a pink plant, what is the probability that their offspring would have pink flowers? Show all your work.

8. Human blood types are determined by co-dominant alleles (A and B). If a man with BB blood had children with a woman with AB blood, what is the chance that their children would have AA blood? Show all your work.

9. Distinguish between positive, negative, and neutral mutations.
10. Explain how natural selection results in the increasing abundance of selected alleles.

11. Compare and contrast (similarities and differences) natural and artificial selection.

12. What are some of the risks of modern agricultural practices?