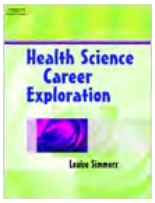
UNIT A
INTRODUCTION TO BIOTECHNOLOGY

	Unit/Competency/Objective	Cognitive	Performance
A	**INTRODUCTION TO BIOTECHNOLOGY**		
EB01.	**Analyze basic concepts and historical development of biotechnology.**	**4%**	**1%**
EB01.01	*Describe concepts and examples of biotechnology.*	*1%*	
EB01.02	*Discuss historical applications of biotechnology.*	*1%*	
EB01.03	*Analyze specific contributions to biotechnology by notable figures in history.*	*2%*	*1%*

Unit Materials

EB01.01	PowerPoint	◆ Everywhere You Look
	Activity	◆ Everywhere You Look
	PDF From CD	◆ Everywhere You Look
	Activity	◆ Areas of Biotechnology
	Activity	◆ Areas of Biotechnology – Review Exercise
	Video	◆ Bioscience: Real Jobs, Real People
EB01.02	Content	◆ Biotechnology Timeline
	Lesson	◆ Each One, Teach One
EB01.03	Activity	◆ Notable Figures in History
	Content	◆ Notable Figures in History

Recommended Resources



First Edition
Author: Louise Simmers
ISBN #: 1401858090
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Binding: Hardcover
Pages: 340
Publisher: Delmar Learning

Bioscience: Real Jobs, Real People

$25 - A video about biotechnology careers that follows four high school students as they visit working companies on “Bioscience Career Day.” During the ten-minute film, these students talk with individuals in a broad range of careers such as research, product development, manufacturing and management. (Ordering Information from the Biotechnology Institute on page A.2)

Recommended Resources (continued)

Biotechnology Industry Organization
1225 Eye Street, N.W., Suite 400
Washington, DC 20005
(202) 962-9200
www.bio.org

http://www.bio.org/news/everywhere.pdf

Supplemental Resources

The following tools could serve as supplemental resources in future units. The ordering information is the same as for Bioscience: Real Jobs, Real People and is listed below.

DNA and Genes Odyssey CD-ROM and Videotape.
$49 - The CD-ROM includes presentation overheads, accompanying Teacher's Guides for the overheads, the Gene Scene and Genetic Mapping animations. The videotape provides classroom ready copies of the Gene Scene and the Genetic Mapping animations.

***Your World* Genome Set (GS1): $84, a savings of $25**
This package includes: DNA and Genes Odyssey CD-ROM and video tape described above, Cracking the Code of Life issue (30 copies and a Teacher's Guide), Genes & Medicine issue (30 copies and a Teacher's Guide)

How to Order from the Biotechnology Institute

Online
Go to http://www.biotechinstitute.org/yw_sub_form.html and fill in the form page and click the submit button below.
Download
Choose to download and save. Use the "File, Save" utility of your browser to save this page to fill out later or share with colleagues.
By mail
You can print out and send the order form to:
Your World Publisher
Biotechnology Institute
1840 Wilson Boulevard
Suite 202
Arlington, VA 22201
By fax
Print out and fax the order form to **703.248.8687**
By telephone
Have your Visa, MasterCard, or Purchase Order number ready and call: **800.796.5806**
Subscribe to *Your World* magazine
As a subscriber you receive both the fall and spring issues of *Your World*, copies for your students and a Teacher's Guide

Lesson Plan

EB01.01 DESCRIBE CONCEPTS AND EXAMPLES OF BIOTECHNOLOGY.

Activity	Steps	Comments
Introduction of Unit	1. In small groups of 3-4, have students write down everything they know about biotechnology. 2. Allow students to share their group results.	• Good introductory activity. Allows teacher to see what the students know, and gives students a chance to get to know each other. • Encourage creative thinking.
Introductory PowerPoint – Everywhere You Look	1. Load the power point presentation. 2. Introduce Biotechnology using the PowerPoint presentation. 3. Have students answer the questions on the handout after the presentation.	• Introduces students to the core of the course • This information comes from the PDF "Everywhere You Look" from the Biotechnology Industry Organization. It is available on your course CD or from www.bio.org. The teacher should share the content details with the students when showing the PowerPoint. Another option is to give students a copy of the brochure as a reading assignment.
Areas of Biotechnology	1. Follow the instructions on the activity page.	• The teacher may wish to laminate all the paper items used in this activity.
Areas of Biotechnology – Review Exercise	1. Follow the instructions on the activity page.	• This activity gives students a chance to move around the room, interact, and review course content.
Video - Bioscience: Real Jobs, Real People	1. Provide students with a copy of the study guide for this video. 2. Show the video: Bioscience: Real Jobs, Real People	• This video is available from the NC Biotechnology Center. Information on ordering this video for $25 is included in the supplemental resource section of this unit.

EB01.02 DISCUSS HISTORICAL APPLICATIONS OF BIOTECHNOLOGY.

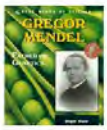
Activity	Steps	Comments
Timeline Activity	1. Assign one historical event per student. (Some students may have 2 or some events may be duplicated, depending on the size of the class.) 2. Have students illustrate their event on one side of the cardstock and in very tiny print, write the date and description of the event on the other side.	• Materials: One sheet of cardstock (8 ½ X 11) for each student. If the class is small, you may give two sheets per student. • One copy of the Timeline per student
Each One, Teach One	1. Implement the "Each One, Teach One" lesson.	• This activity uses the cards the students created.
Timeline Lineup	1. Give back to each student the card that he or she created. 2. Ask students to put away all notes and the timeline and just keep out the history card. 3. Explain to students that this next activity must be done in total silence – non verbal communication only and no writing notes. 4. Tell the students that, on your signal, they are to hold their card in front of them so nobody can see the date and description on the back. 5. As quickly as possible they are to line themselves up in chronological order.	• This activity can be done as a whole class or in two teams. • This activity provides a good review of the timeline. • Sometimes it is helpful to remind students that this is a "trust" activity – the goal is not winning, it is learning, and therefore, cheating is not acceptable.

EB01.03 ANALYZE SPECIFIC CONTRIBUTIONS TO BIOTECHNOLOGY BY NOTABLE FIGURES IN HISTORY.

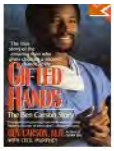
Activity	Steps	Comments
Notable Figures in History	1. Give students a copy of the handout that outlines the notable figures in history, and the activity assignment sheet. 2. Divide the class into nine groups, one for each notable figure. 3. Allow one day for research, 1-2 days for script writing and practice, and 1-2 days for class performances. 4. Students may need encouragement in the creative process and in elaboration with their writing. 5. Have audience members take notes of important facts presented in the skits.	▪ Regarding groups – If there are fewer than 18 students in the class, you may allow groups (pairs) to select their notable figure. ▪ Students should be grouped by the teacher to create groups of mixed achievement levels. ▪ If possible, schedule research time in a computer lab with Internet access, or a day in the Media Center. ▪ You may wish to videotape the skits. ▪ You may allow the audience to score one area of the assignment – for example: F. Overall Impression – 20 points. Have all students turn in their rating of the performance (up to 20 points) and average the score to incorporate into the final total. ▪ More information about these historical figures can be found in Chapter 1 of *Health Science Career Exploration*.

Opportunity for Parental Involvement – Invite parents to the school to view the skits.

Challenge Activity – Reading opportunity to encourage extended learning, for example:



- **Gregor Mendel: Father of Genetics (Great Minds of Science)** by Roger Klare **Paperback:** 128 pages ; Enslow Publishers, Inc.; (July 2001) **ISBN:** 0766018717

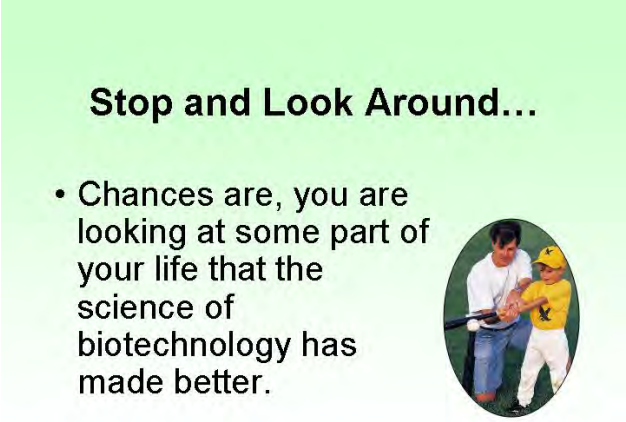


- **Gifted Hands** by Ben Carson, Cecil Murphey (Contributor) **Mass Market Paperback:** 224 pages ; Zondervan; (December 8, 1996) **ISBN:** 0310214696

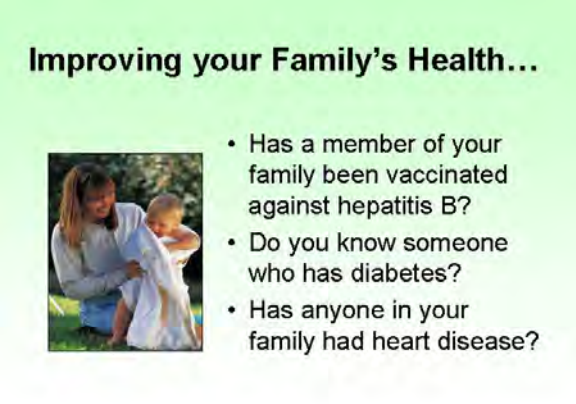
Content

EVERYWHERE YOU LOOK – POWERPOINT SLIDES

Slide 1



Slide 2



Slide 3

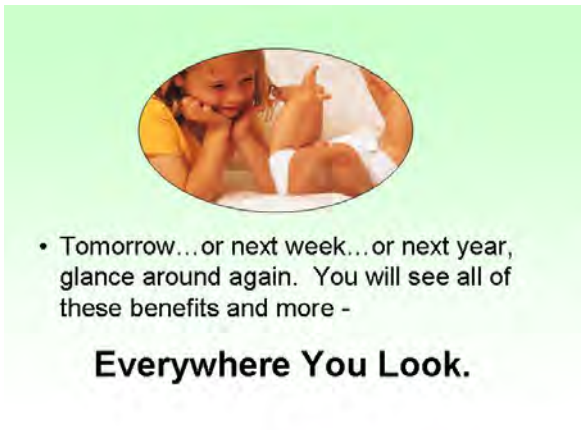
Slide 4

Slide 5

Slide 6

Slide 7

Slide 8



Slide 9

Activity

Name_____ Period_____

EVERYWHERE YOU LOOK

After viewing the PowerPoint slides or reading the brochure "Everywhere You Look: Biotechnology Touches Your Life" answer the following questions.

1. Scientists often say that biotechnology is an exciting field of study. Why do you think they would say that?

2. As you are leaving school, a TV reporter stops you and asks, "What are you going to learn in that Exploring Biotechnology class?" What would you say?

3. What is the most interesting thing you learned today?

4. Choose 5 different careers and briefly explain why you think a person in that career would use biotechnology.

Activity

AREAS OF BIOTECHNOLOGY

TEACHER PREPARATION:

1. Copy the large headings (Agriculture, Industry, Environment, Medicine) on colored, cardstock paper. You may wish to use a different color for each heading.
2. Copy the list of examples of how Biotechnology is used in each of the areas.
3. In a plastic storage bag or envelope, place one of each of the headings and one of each of the examples (cut into strips). Mix them up by shaking.
4. Prepare enough bags/envelopes so you have enough for 2 students to share each.
5. You may wish to create a label that contains the student directions listed below. The label can then be affixed to the front of the bag/envelope.

STUDENT DIRECTIONS:

1. Remove the headings Agriculture, Industry, Environment, Medicine from the bag/envelope.
2. Lay the headings across the top of your desk/table so that you create columns for each heading.
3. Reach into the bag and remove one of the strips of paper that describes how biotechnology is used in everyday life. Determine which area of biotechnology the example would represent. Place that example under the appropriate heading. Continue this until all the examples have been categorized.
4. Record at least 5 examples for each area on a piece of notebook paper.

AGRICULTURAL
FOOD AND CONSUMER GOODS
ENVIRONMENT
MEDICINE

AGRICULTURAL EXAMPLES

Biotechnology may make it possible to customize the genetic makeup of crop plants so they can grow in exceptionally dry or wet, hot or cold climates.
Scientists have inserted the genes that code for therapeutic proteins into a variety of commonly grown crops such as tobacco, corn and soybeans.
Many animal feed products are enhanced with proteins to boost nutrition and control disease.
Corn with the Bt gene is an insect-protected variety that provides a high level of genetically introduced protection against European corn borer and corn earworm, protecting crops from ear damage and yield loss.
Approved in 1996, Roundup® Ready cotton is resistant to applications of Roundup® herbicide designed to kill weeds. Farmers have to spend less time plowing fields and their crop production increases.
Bovine Somatotropin (BST) BST is a naturally occurring protein hormone in cows that causes them to produce milk. BST improves milk production by as much as 20 percent and is now used by farmers in over 30% of the nation's cows.

FOOD AND CONSUMER GOODS EXAMPLES

Lactaid® milk products produced using the enzyme lactase.
Using microbial fermentation to produce an abundant amount of pepsin or rennet (naturally found in a cow's stomach) for cheese production.
Fabric detergents are becoming more effective because of the addition of enzymes to their active ingredients.
Fruit juices are made using the enzyme pectinase which breaks down the pulp into juice.
Contact lens solutions contain enzymes to break down proteins that build up on lenses.
Microbes are grown so that their amino acids can be used to produce a product such as Equal® sweetener.

ENVIRONMENT EXAMPLES

Using methane-producing bacteria (or methane gas from waste lagoons) to heat homes in third-world countries.
Sewage plants collect methane gas to fuel generators or air compressors.
There is a fungus which is used to break down a wood preservative that contaminates the soil near old sawmills.
Microbes can clean up waste water before it enters streams and lakes.
Microbes are capable of cleaning up fuel spills from gas stations.
Following the major oil spill in Alaska's Prince William Sound, natural oil-eating bacteria to help clean up the mess were used. Follow-up studies suggest that the microbes did as good a job in cleaning up soiled beaches as high-pressure hoses and detergents could have done.

MEDICINE EXAMPLES

Flu vaccine that is not a shot- it is a nasal spray.
New tests (assays) to diagnose inherited diseases and common illnesses like strep throat have been developed through Biotechnology.
Test strips that indicate the level of glucose in the blood (biosensors).
Monoclonal antibodies that fight cancer cells.
Human Genome Project- to locate and identify every gene in the human body and what it does.
Human growth hormone to counteract dwarfism.

Activity

AREAS OF BIOTECHNOLOGY – REVEW EXERCISE

This activity also helps student learn about various applications of Biotechnology in agriculture, industry, the environment and medicine. It can be used as a review exercise in the classroom.

TEACHER PREPARATION:

1. Write the large headings (Agriculture, Industry, Environment, Medicine) on a large piece of paper and place the headings on the wall in the four corners of the classroom.
2. Cut up the examples of biotechnology in the previous activity and place them in a box or bag.

ACTIVITY:

3. Have each student select one example of biotechnology.
4. Have students read their example and then go the corner of the room with the sign that corresponds to the area of biotechnology represented on their slip of paper.
5. Have students compare their area of biotechnology with those in their group to decide if everyone belongs in that group. If anyone is in the wrong place the group should help them find the proper corner.
6. When all the groups are correct, have students write down the examples of biotechnology from their group.
7. Have each group share their examples of biotechnology. Students in other groups should take notes as needed.

SUMMARY:

8. Administer a teacher-made quiz on the areas of biotechnology.

Activity

Name _____ Date _____

BIOSCIENCE: REAL JOBS, REAL PEOPLE
STUDENT GUIDE

Directions: As you watch the video, fill in the answers to the questions about the people that work in the Bioscience industry.

1. Some bioscience companies use biotechnology to make _____ or vaccines.

2. What was Chad Scott's college major? _____

3. What is one way to get the experience that employers are looking for?
   _____

4. The project Chad is working on is looking to regenerate nerves for people that suffer from what disease? _____

5. Quality Biological develops and prepares media used in _____ and _____ _____.

6. Some of the media is used for NIH and _____ research.

7. In the field of Biotechnology, solutions are made for cultivating _____.

8. TIGR is a government funded project to sequence the _____ of various organisms.

9. A research associate does _____ work at the bench.

10. If you have an associate degree, you can work as a _____ _____ in the lab.

11. What is gene therapy? _____
    _____

12. It is important to take science classes, but you should also take _____ and _____ classes.

13. What information in the video was the most interesting to you?

14. If you had to choose one of the careers introduced in the video, which one would you choose and why?

Content

BIOTECHNOLOGY TIMELINE

Year	Event
1750 BC	The Sumerians brew beer.
400 BC	Hippocrates, the “Father of Medicine” created a high standard of ethics and wrote the Hippocratic Oath.
1797	Jenner inoculates a child with a viral vaccine to protect him from smallpox.
1863	Mendel, in his study of peas, discovers that traits were transmitted from parents to progeny by discrete, independent units, later called genes. His observations laid the groundwork for the field of genetics.
1883	The first rabies vaccine is developed by Louis Pasteur.
1906	The term "genetics" is introduced.
1928	Fleming discovers penicillin, the first antibiotic.
1952	Rosalind Franklin produces early data about the structure of DNA.
1953	Watson and Crick reveal the three-dimensional structure of DNA.
1970	Dr. Norman Borlaug, agricultural researcher and pioneer in feeding the world’s population, wins the Nobel Price for Peace.
1973	Cohen and Boyer perform the first successful recombinant DNA experiment, using bacterial genes.
1978	The first test tube baby, Louise Brown, was born in England.
1981	Acquired Immune Deficiency Syndrome (AIDS) was identified as a disease.
1982	Humulin, Genentech's human insulin drug produced by genetically engineered bacteria for the treatment of diabetes, is the first biotech drug to be approved by the Food and Drug Administration.
1984	The DNA fingerprinting technique is developed.
1987	Dr. Ben Carson was the first surgeon to successfully separate Siamese twins joined at the head.
1988	Congress funds the Human Genome Project, a massive effort to map and sequence the human genetic code as well as the genomes of other species.
1990	The first federally approved gene therapy treatment is performed successfully on a 4-year-old girl suffering from an immune disorder.
1997	Ian Wilmut (Scotland) is credited with cloning a sheep, Dolly, using DNA from adult sheep cells.
2001	President Bush decides to permit federal funding of research using existing stem cell lines, allowing researchers to continue seeking cures for debilitating diseases such as Alzheimer's and Parkinson's.

Thanks to the North Carolina Biotechnology Center for contributions to this timeline.

Lesson

EACH ONE, TEACH ONE

1. Divide students into groups. Explain to students, “In this activity, you will have two roles: a teacher and a learner.”

2. “You have created a card (or two) on which you illustrated a historical fact in the development of biotechnology. Your job is to teach that one fact to everyone else in your group. Use whatever teaching strategies you wish to use to help your classmates learn about your fact and the year it took place. At the same time you are teaching your fact, you will also be learning as many facts as possible. Your goal is to be a good teacher and a good learner.”

3. “There will be an evaluation at the end of the activity in which the good teachers and the good learners will be recognized.”

4. Any questions? [Distribute cards - one to each student.] “You may begin.” The less instructions you give at this point the better; different groups will approach this activity differently - that's fine! Students like to talk and students like to move - this activity incorporates both.

5. Walk among the group to observe methods being used. Make sure you have overhead projector with blank transparency and overhead marker ready during this time.

6. When it is obvious it is time to stop, have everyone return to their seats.

7. “Now it is time for your evaluation - this will be a group evaluation. Place the card with the fact you were teaching in a pile in the center of the table. A [The teacher should pick up the cards.] “Also, any notes you may have taken during the exercise should be turned face down.”

8. I want you to think of a fact someone else taught you - raise your hand when you have done so. I will call on you to share the fact.” [As students share facts they remember, be sure to write the facts on the transparency so the visual learners can see them in print. Also, as facts are shared, ask the student who taught that fact to stand and take a bow.

9. After all facts have been shared, or until no one is able to remember another fact, have all the students who shared a fact stand and take a bow. Recognize them as good learners.

Activity

NOTABLE FIGURES IN HISTORY

Group Members _____
_____
_____
_____

Notable Figure _____

1. **Assignment** - Your group has been assigned a notable figure history. Your assignment is to research a notable figure in history, write a skit about an aspect of the person's life, and act out the skit for your class.

2. **Research** – Your teacher will tell you your research options. Most students find excellent information on the Internet. The school media center may also have information. You will need the information from at least three good resources.

3. **Review** – Review the material you collected. As a group, determine what aspect of the person's life and contributions to biotechnology that you would like to share with the rest of the class.

4. **Script** – Write a skit that includes all the members in your group. The skit should be of an important event in the person's life. Much of what you write will be speculation on your part. You should be able to imagine what was done and said so that you can write a skit that is both entertaining and informative.

5. **Purpose** – The purpose of this activity is to give you an opportunity to learn about a specific person, think deeply about an event in the life of that person, and share the person's story with the rest of your class. You will want to use dialogue that clearly explains the event so that it is understandable to others.

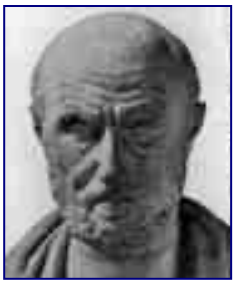
6. **Grading** – The following rating scale will be used.

a.	**Research** (All members participated and stayed on task)	**10 pts**
b.	**Script – Content** (Story of event well told)	**20 pts**
c.	**Script – Creativity** (Evidence of thought and creativity)	**10 pts**
d.	**Script – Composition** (Neatness, spelling, grammar)	**10 pts**
e.	**Acting** (Group preparation and presentation)	**15 pts**
f.	**Overall Impression** (Effectiveness of skit in telling the story.)	**20 pts**
g.	**Time** (3-5 minutes)	**5 pts**
h.	**Group Work** (Teamwork, behavior during other skits)	**10 pts**
	TOTAL	**100 pts**

Content

NOTABLE FIGURES IN HISTORY

HIPPOCRATES



Hippocrates was born in Greece in 460 B.C. His father was a physician and as a young man, Hippocrates traveled the world (or what part of it was known at the time) and learned about medicine.

Hippocrates studied the human body and made observations of his work. Eventually he developed his own theories of illness and rejected the current belief that illness was caused by evil spirits and by making the Gods angry.

Hippocrates founded a medical school on the island of Cos and began teaching his ideas. He taught that the body should be treated as a whole. He believed in treating illness with rest, a good diet, fresh air and cleanliness.

Hippocrates is known as the Father of Medicine and is credited with developing the ideas and principles of the Hippocratic oath, taken today by physicians before they begin their medical practice.

He died in 377 B.C.

LOUIS PASTEUR

Louis Pasteur was born in a small town France in 1822. His father was a tanner.

Pasteur was a bright young man and by 1847 had earned a doctorate in Physics and Chemistry. He continued his research for many years and is credited with a number of discoveries.

Pasteur founded the science of microbiology. He also proved the germ theory of disease and invented the process of pasteurization. He discovered that weakened forms of a microbe can be given to a person who then develops his or her own immunity to the disease. As a result, he developed vaccines for several diseases, including rabies. Pasteur was responsible for influencing changes in hospital practices to minimize the spread of microbes.

Pasteur died in 1895 at the age of 73.

GREGOR MENDEL

Gregor Mendel was born in 1822 in Austria to peasant parents. At the age of 21 he entered a monastery to study philosophy, theology and natural science. While at the monastery, Mendel experimented with flowers in the monastery's gardens, trying to develop new color variations. It was these experiments that led to his experiments in hybridization. Between 1856 and 1863 he cultivated and tested almost 28,000 plants. He did much of his research with pea plants because they were easy to obtain and cultivate.

Mendel's work was not well understood or appreciated in this lifetime. It wasn't until 1900 that three scientists from three different countries in Europe did similar experiments and came across the research done by Mendel.

Through his remarkable research on plant hybrids, Mendel established that there does exist, in living things, dominant and recessive characteristics. (Mendelian Law). He is often called the father of genetics.

Mendel died in Austria in 1884.

ROSALIND FRANKLIN

Rosalind Franklin was born in London in 1920, the daughter of well-to-do Jewish parents. When she was 15 years old she announced to her family that she wanted to be a scientist, and in 1938, she entered Cambridge University. She earned her PhD at the age of 26 and began working on x-ray diffraction – using x-rays to create images of crystalized solids.

In 1950 she was invited to King's College in London to join a team of scientists studying living cells. She was assigned to work with Maurice Wilkins, but their relationship was not good. Rosalind Franklin knew what she wanted to accomplish and went about her business, much to the dismay and envy of Maurice Wilkins.

In her two years at King's College, Franklin made advances in x-ray diffraction techniques with DNA and extracted finer DNA fibers than ever before, arranging them in parallel bundles, and discovering crucial keys to DNA's structure. Wilkins stole her data and shared it with Watson and Frick, who are credited with the discovery of DNA's structure.

Rosalind Franklin died from ovarian cancer in 1958 at the age of 37.

JAMES WATSON AND FRANCIS CRICK

In 1962, along with their colleague Maurice Wilkins, James Watson and Francis Click were awarded the Nobel Prize for their work in the discovery of DNA's structure in 1953.

James Watson was 25 years old at the time of the discovery. He was born in Chicago and was working in England. He had a master's and doctorate in zoology when he became interested in genetics.

Francis Crick was a British citizen and a physicist in biology. He was working at Cambridge when he met James Watson. They shared an interest in DNA that eventually led to their determination that DNA carries life's hereditary information.

STANLEY COHEN AND HERBERT BOYER

Stanley Cohen and Herbert Boyer are scientists. Stanley Cohen was a Professor of Medicine at Stanford University and Herbert Boyer a biochemist and genetic engineer at the University of California. They got together at a conference in 1972. In 1973 they invented the technique of DNA cloning that allowed genes to be transferred between different biological species. As a result they are credited with the birth of genetic engineering. It was their work that opened the doors for the biotechnology revolution.

In 1976 they founded Genentech, Inc., a world leader in biotechnology research.

DR. BEN CARSON

Ben Carson grew up in inner-city Detroit and Boston. His parents divorced when Ben was eight years old, and he and his brother were raised by their mother. Ben struggled in school as a child with failing grades, low self esteem and behavior problems.

In high school Ben turned himself around, and eventually earned a scholarship to Yale University. He continued his studies at the University of Michigan Medical School where he studied neurosurgery. After graduating, he moved on to Johns Hopkins University where he later worked his way up to Director of Pediatric Surgery at age 32.

Dr. Carson gained world-wide recognition in 1987 when he became the first surgeon to successfully separate Siamese twins who were joined at the back of the head.

DR. NORMAN BORLAUG

Norman Borlaug was born in Iowa in 1914. He grew up on his father's farm and attended a one room school house for eight years. He earned a B.S. in forestry, M.S. in forest pathology, and Ph.D. in plant pathology and genetics from the University of Minnesota.

For thirty years, Dr. Borlaug worked as an agricultural researcher. His efforts focused on improving wheat. Dr. Borlaug won a Nobel Prize for Peace in 1970 in recognition of his work to improve living conditions for millions of people in developing countries.

The "Father of the Green Revolution" continues his battle against starvation in Africa today.

DR. IAN WILMUT

Ian Wilmut was born in England in 1945. He earned his bachelor's degree in agricultural science and his PhD from the University of Cambridge in 1971. His early research at Cambridge led to the birth of the first calf, "Frosty", from a frozen embryo.

Since 1974 he has worked in his laboratory at the Roslin Institute in Edinburgh, Scotland. He gained recognition from around the world when his team of scientists successfully cloned an adult mammal for the first time. Dolly the sheep was born in 1996.

Dr. Wilmut continues to do research on the cloning of human embryos to provide stem cells for the treatment of degenerative disorders such as diabetes and Parkinson's disease.

EVERYWHERE YOU LOOK



Biotechnology Touches Your Life

STOP AND LOOK AROUND...

Chances are, you are looking at some part of your life that the science of biotechnology has made better.

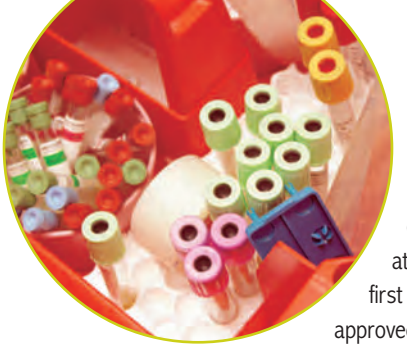
Improving Your Family's Health

If you are with your family right now, you're looking at people who are benefiting from biotechnology. Give them a hug, and read on.

Has a member of your family been vaccinated against hepatitis B, either separately or as part of an infant or childhood vaccination regimen? If so, you have biotechnology to thank for protection against this sometimes fatal disease that attacks millions of people each year. Because the vaccine prevents infection-related liver damage that can result in liver cancer, the Centers for Disease Control and Prevention calls this "the first anti-cancer vaccine."

Do you know someone who has diabetes? Before 1982, there were few options for

insulin-dependent diabetics who were allergic to animal-derived insulin. That year, a human version of the drug entered the market — the first ever biotechnology medicine to be commercialized. Recombinant insulin is still saving lives today, and the next few years may bring inhaled forms of insulin and other new diabetes drugs that reduce the devastating impact of this disease.



Has anyone in your family had heart disease? Heart disease is still the number one killer of adults, but its toll is dropping. From 1990 to 2000, the U.S. death rate from coronary heart disease dropped 25 percent, due in part to the introduction, beginning in 1987, of new biotechnology-based "clot buster" drugs, which allow emergency room doctors to dissolve blockages during heart attacks. The first drug approved in this class is now used to treat a stroke in progress. The result is that a significant percentage of the 600,000 victims of stroke each year may have reduced permanent disability if this treatment is received quickly.

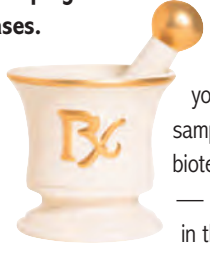
If a member of your family is diagnosed with breast cancer, leukemia, lymphoma or another cancer, it will help you to know that biotechnology has developed therapies over the past 20 years that are working wonders. A growing percentage of cancer patients survive and return to good health thanks to these breakthroughs.

Some diseases are more likely to strike the women in your family. Rheumatoid arthritis is a good example. The disease affects two million people —

More than 325 million people worldwide have been helped by the more than 150 biotechnology drugs and vaccines approved by the U.S. Food and Drug Administration.

mostly women — often during early or middle adulthood. Today, biotechnology drugs that slow the painful joint-destroying progression of the disease are helping tens of thousands of women with RA to maintain active lives.

Biotechnology is also helping people with rare diseases. You've probably never heard of most of these diseases, but combined they affect 25 million Americans. Over the last 20 years, more than 230 medicines for rare diseases have been introduced, and today biotechnology is behind about two-thirds of the new medicines in development for conditions such as multiple sclerosis and cystic fibrosis.



These improvements in health care for you and your family are just a small sample of the benefits biotechnology has delivered — and will continue to bring in the future. New products in advanced testing or under consideration for approval at the Food and Drug Administration include medications for osteoporosis, psoriasis, lupus, stroke, HIV (both treatments and vaccines), sickle cell disease, drug-resistant tuberculosis, hepatitis, chronic fatigue and rare genetic diseases. Altogether, more than 370 biotechnology products are in late-stage development.

Improving Everyday Life...

Sometimes biotechnology has the biggest impact in places you never notice.

When you made coffee this morning, you probably didn't realize the filter was made with a biotechnology process that uses enzymes to bleach the paper, reducing the amount of chlorine and energy used in manufacturing. The vitamin C and vitamin B2 you gulped this morning may have been made with a biotech process that eliminates the use of toxic chemicals during their manufacture.

The cornflakes in your cereal bowl were grown using fewer pesticides,

thanks to the development of corn that is resistant to insects and disease. The bread for your toast contains biotech food enzymes that help the bread rise and keep it fresh. Biotech enzymes are used to remove lactose from milk to help people who are lactose intolerant. Other enzymes are used in brewing beer or in making flavors like vanilla.

Take a look on the shelves of your kitchen cabinets. You will find products made with canola oil that contains virtually no transfats and uses fewer pesticides, thanks to biotechnology. Other food products that are grown with less environmental impact include corn, canola, soybeans and soybean oil.

Any cheese in the 'fridge? For more than 20 years, the cheese you eat has been created with a biotech enzyme, chymosin. The enzyme is found naturally in calves and used to curdle milk during the cheese production process. Using biotechnology to create the enzyme results in more plentiful and purer supplies, while eliminating the need to use animals for this purpose. The biotech enzyme is used in approximately 60 percent of all hard-cheese products.

In fact, more than 70 percent of processed foods in the supermarket contain ingredients improved through biotechnology — oil and meal from soybeans, corn, canola and cotton. These biotech

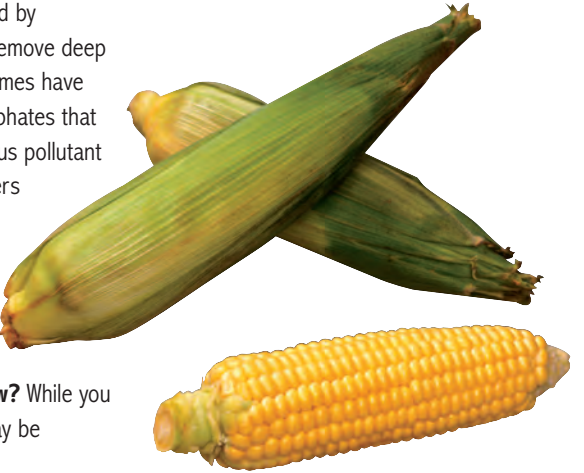
The bread for your toast contains biotech food enzymes that help the bread rise and to keep it fresh.

products have reduced the amount of synthetic pesticides in the environment and water supply by hundreds of millions of pounds.

After more than two decades of success in health care and food production, scientists are now looking for ways to use biotechnology to make the manufacture of common products — like plastic and fuel — cleaner, more efficient and more sustainable through the use of renewable resources.

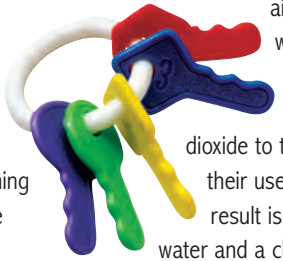
How does all this affect your everyday life? For starters, the cotton clothing your family is wearing right now was made from cotton plants that need fewer pesticides, thanks to biotechnology. The faded jeans you don on the weekend were given that special look using biotech-derived enzymes. Plus, every time you take fresh clothes out of the dryer you're benefiting from the detergent enzymes developed by biotechnology to remove deep stains. These enzymes have replaced the phosphates that used to be a serious pollutant of the nation's rivers and streams.

How many plastic products can you see right now? While you and your family may be concerned about the enormous use of petroleum products for energy, the plastic products that surround you in your home or



New plastics are coming into your home made from corn and other plants, not petroleum...

office are also made from oil — much of it from overseas. That may be changing forever, very soon.



New plastics are coming into your home made from corn and other plants, not petroleum, via a biotechnology process. Think of the impact on the environment: the plants themselves will be taking carbon dioxide out of the air as they grow, while delivering products that do not add carbon dioxide to the atmosphere in their use or disposal. The result is cleaner air, cleaner water and a cleaner planet for your children.

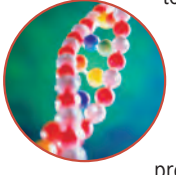
New fuels like "biodiesel" and bioethanol are entering the market. Biodiesel is made by extracting oils from soybeans and other crops. And new biodegradable greases and lubricants for the family car are also being made from agricultural crops. Bioethanol can be made from corn, or — by using new biotech processes — from agricultural waste products like wheat straw, cornhusks, rice straw or even grass clippings.

Biotechnology is also applied in more direct ways to environmental cleanup. A process called bioremediation uses microorganisms to reduce, eliminate or contain contaminants.

The Future...

Tomorrow, biotechnology will bring you better health.

Biotechnology is the future of medicine. More than 370 new biotechnology medicines are in clinical testing for more than 200 diseases. And with the completion of the human genome sequence, alongside new maps detailing millions of genetic variations, scientists now have a wealth of new data about the fundamental basis of health and disease right at their fingertips. They are already using this information to develop diagnostics to help you and your family plan preventative care, by telling you which diseases you need to worry about based on your genetic profile. Genetic information soon will help your doctor make decisions about which drugs are



most likely to work for you — and which will cause side effects and should be avoided. And, most importantly, a steady stream of new drugs that work better, with fewer side effects, will appear on pharmacy shelves in the coming decades.

Some of those drugs will be made in plants. Think of them as "green drug factories" that will produce all kinds of medical products you and your family may need.

In some cases, the crops themselves — when grown as food — will help save lives. Millions of people in developing countries suffer from a deficiency of vitamin A, which causes blindness and anemia. Biotechnology has created an experimental new rice, called "Golden Rice," that delivers vitamin A in the single food source that most of the people on Earth depend upon as their primary daily source of sustenance.

Back here at home, take one more look around. There are biotechnology benefits everywhere you look.

These benefits are just a small sampling of the enormous improvements brought by biotechnology over the past 50 years, since James Watson and Francis Crick first described the molecule of DNA. And even as you read this, scientists around the globe are imagining even more improvements, both big and small, to the world in which you live.

Tomorrow...or next week... or next year, glance around again. You will see all of these benefits, and more —

EVERYWHERE YOU LOOK.

The Biotechnology Industry Organization (BIO) represents more than 1,000 biotechnology companies, academic institutions, state biotechnology centers and related organizations in all 50 U.S. states and 33 other nations. BIO members are involved in the research and development of health-care, agriculture, industrial and environmental biotechnology products.

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BIO BIOTECHNOLOGY INDUSTRY ORGANIZATION

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A Healing Gene

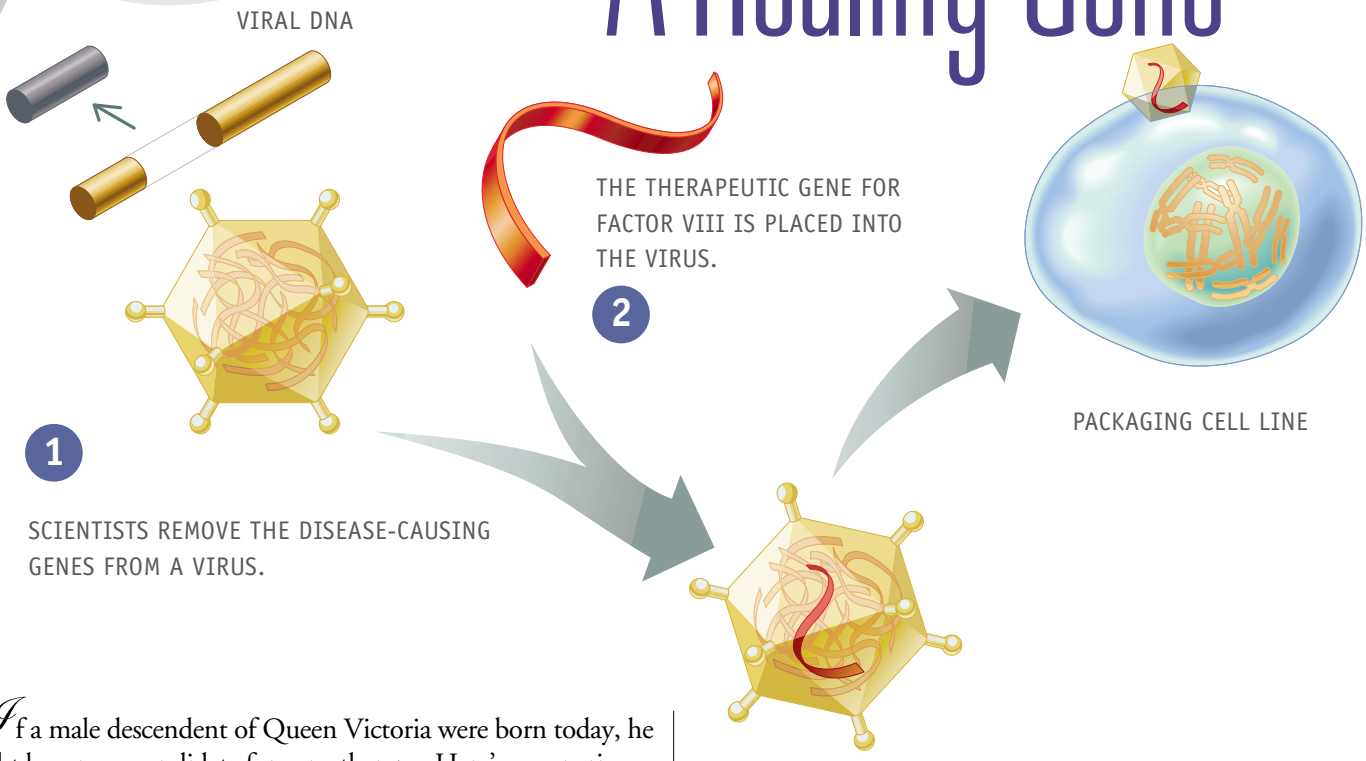


Illustration by RhônePoulenc Rorer Gencell

If a male descendent of Queen Victoria were born today, he might become a candidate for gene therapy. Here's a scenario that may become commonplace in a few years...

Doctors will probably know that his mother is a carrier for the hemophilia gene, so they will test all her male children either before or just after birth. When they learn that the baby boy inherited this gene, they will add a working version of the gene to his cells.

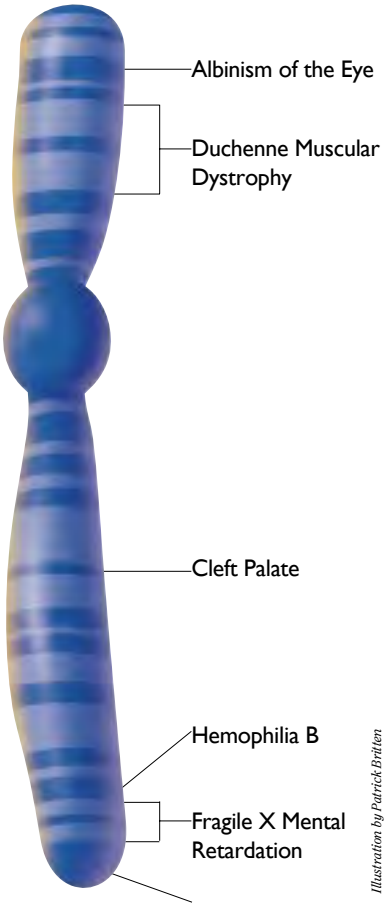
To deliver the gene to the cells, scientists will package it in a delivery vehicle called a *vector*. They will use a vehicle that already delivers genetic information to cells: a virus. Viruses enter a cell, deliver genes, and hijack the cell's machinery so the cell produces the viral proteins. That's how we get a cold or flu. To make a viral vector, scientists remove the viral genes that cause disease, as well as those that allow the virus to reproduce and spread infection. In that way, scientists "tame" a virus so it no longer can cause harm but can still deliver genes.

Next, scientists will insert a helpful or *therapeutic* gene into the virus, in this case, the gene for Factor VIII. With this new gene on board, the virus still infects a cell, but instead of spreading illness, it contributes to health!

For this little boy, doctors will inject the virus into his muscles. It may seem odd that they won't put it in his liver, since liver cells normally produce the clotting proteins. Still, the liver cells themselves don't use the blood clotting factors. Rather, the proteins leave the liver and circulate in the blood to do their job. It does not matter whether they are made by the liver or another organ. After the injection, the boy's muscles will become permanent factories for the blood clotting protein 'round the clock.

The boy may think this gene therapy shot is just one more childhood vaccine! He may need a "booster" shot as he becomes an adult. Otherwise, he will be free to play without fearing every scraped knee.

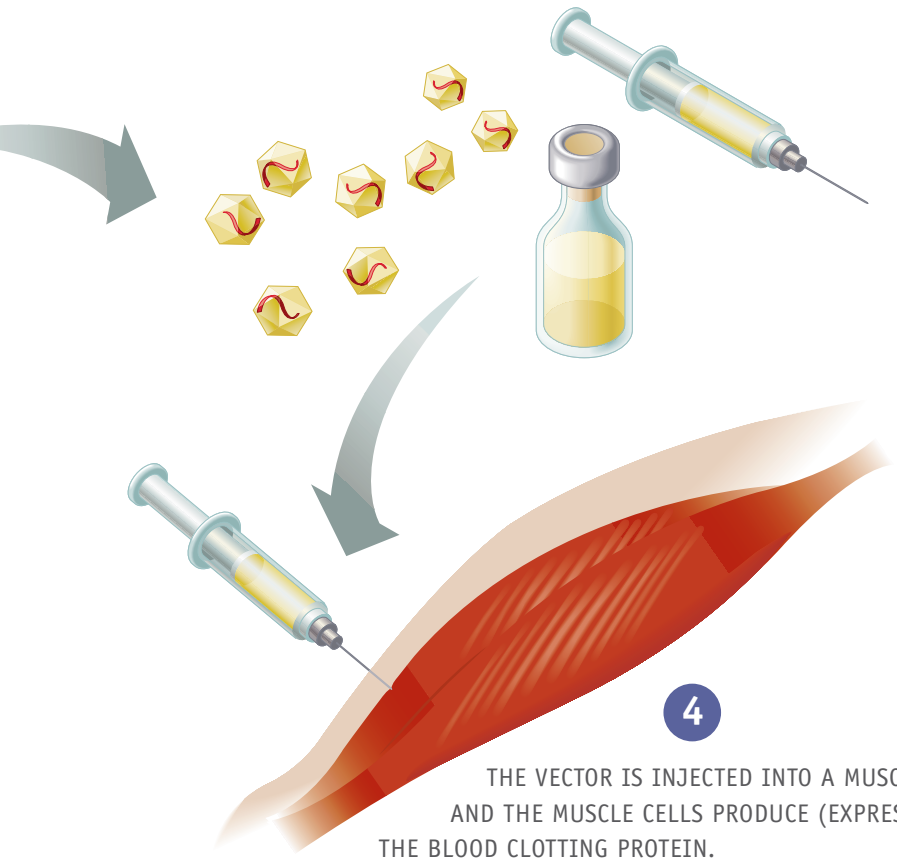
These techniques may be adapted to treat other diseases that need specific proteins in the blood. Still other diseases require quite different approaches, and you can read about these challenges on the next page.



This map of the X chromosome shows the location of the Factor VIII gene that causes Hemophilia A, as well as some other disease genes.

Illustration by Patrick Britten

3 MANY COPIES OF THE VECTORS ARE PRODUCED IN A LABORATORY CELL CULTURE. A LARGE AMOUNT OF THE VECTOR IS NOW AVAILABLE FOR GENE THERAPY.



4 THE VECTOR IS INJECTED INTO A MUSCLE, AND THE MUSCLE CELLS PRODUCE (EXPRESS) THE BLOOD CLOTTING PROTEIN.

This illustration shows one gene therapy experiment to treat hemophilia, a disease caused by a defective gene for the blood clotting protein, Factor VIII.

thoughts on the future

JIM WILSON, M.D., PH.D., DIRECTOR, INSTITUTE FOR HUMAN GENE THERAPY AND JOHN HERR MUSSER PROFESSOR, CHAIRMAN, DEPARTMENT OF MOLECULAR AND CELLULAR ENGINEERING, UNIVERSITY OF PENNSYLVANIA

"Gene therapy will eventually be able to treat diseases that need careful regulation of a protein. For example, treating diabetes requires carefully adjusting the amount of insulin in the blood. We will construct the therapeutic gene with regulatory elements that we can control externally. We could insert a gene into your cells, but the gene will stay off until you take a pill that triggers the cell to turn it on. The higher the dose of the pill you take, the more protein the gene will express. You could monitor the protein level in the bloodstream and adjust the dose of pill to achieve just the right balance. This could provide an easier, safer, and more effective treatment for diabetes and hemophilia, or it could activate a cancer therapy."

Genes, Inheritance, and Disease

- Every cell in our body (except red blood cells) has a nucleus.
- Each nucleus contains 23 pairs of chromosomes: one chromosome in each pair from our mother and one from our father.
- Chromosomes are made of DNA (DeoxyriboNucleic Acid).
- DNA forms the shape of a twisted ladder or "double helix."
- Four bases [adenine (A), thymine (T), cytosine (C), and guanine (G)] are attached at each rung position.
- The bases attached to the two strands are complementary, with A opposite T and C opposite G.
- These complementary combinations, called base pairs, form the "rungs" of the ladder.
- The sequence (order) of bases along the DNA strands contains the coded information of life.
- Sections of DNA form genes, which are arranged in a specific order on a chromosome.
- Each gene contains thousands of base pairs and their sequence creates a pattern for building a specific protein.
- Small mutations or "misspellings" in the DNA sequence can change the final protein and may lead to a genetic disease.
- If a defective gene in the germline (egg or sperm) causes a disease, it is inherited.
- Environmental factors that damage genes in other cells of the body (called somatic cells) can lead to disease, and that disease is not inherited.

Building a biomanufacturing community

The state's workforce training initiative is part of a highly capable and expanding infrastructure that supports the biomanufacturing industry in North Carolina and makes the state an attractive location for biomanufacturing companies. The biomanufacturing community includes several architecture, construction, engineering, instrumentation and consulting firms that design, build, upfit and validate bioprocessing plants in compliance with FDA requirements. It also includes a large and dynamic chapter of the International Society of Pharmaceutical Engineers and a Bioprocessing and Process Development Focus Group, sponsored by the Biotechnology Center. The Focus Group provides a dedicated forum for process development scientists and engineers in the state to discuss issues, challenges and developments in biomanufacturing.

Biomanufacturers

Company	*Products/Services*	*Location*
Ajinomoto USA	Amino Acids	Raleigh
Archer Daniels Midland	Citric acid	Southport
Bayer	Blood and plasma-related therapeutics	Clayton
Biogen Idec	Multiple sclerosis and psoriasis drugs	Research Triangle Park
Biolex	Therapeutic proteins	Pittsboro
Corn Products International	High-fructose corn syrup and starch	Winston-Salem
Diosynth RTP	Contract biopharmaceutical manufacturing	Research Triangle Park
Embrex*	Poultry vaccine	Laurinburg
Greer Laboratories	Allergenic extracts, vaccines	Lenoir
KBI BioPharma**	Contract biopharmaceutical manufacturing	Durham
Merck & Co.**	Vaccines	Durham
Merix Bioscience	Vaccines	Durham
MWG	Synthetic nucleic acids	High Point
Novozymes	Industrial enzymes	Franklinton
Wyeth Vaccines	Vaccines	Sanford

* Embrex began construction in March 2003.

** KBI began construction in September 2003.

*** Merck announced in December 2003 that it would build a new vaccine plant scheduled to open in 2008.

PREPARING A WORK FORCE *continued*

nities," he said. "This funding and the training community colleges will provide will give them that opportunity."

In addition to the new $64.5 million training initiative described previously, the North Carolina Biotechnology Center has worked with industry and the North Carolina Community College System to develop and produce the BioWork course for training entry level bioprocess technicians in bioprocess, pharmaceutical, and chemical manufacturing. This 128-hour course taught by the community colleges covers basic science, cGMP, and manufacturing technology, giving students the background they need to learn quickly and effectively on the job. The course is offered to the public and is used by companies for in-house training of new hires or incumbent workers.

The North Carolina Community College System also sponsors an annual BioQuality workshop series on cGMP as well as other business and communications topics offered by nationally recognized training organizations such as the GMP Institute and Kepner-Tregoe. Workshops are available at a nominal cost to employees of North Carolina pharmaceutical manufacturing companies.

Nine community colleges have Associate of Applied Science degree programs in biotechnology; bioprocess, chemical, and pharmaceutical manufacturing technology; and laboratory technology. And many university departments across the state have B.S. degrees or areas of concentration in all the foundational disciplines supporting bioprocess and pharmaceutical manufacturing.

CONTACT US

For more information about biomanufacturing opportunities in North Carolina, contact Dr. Ken Tindall, Senior Vice President for Science and Business Development. For information on workforce training, contact Dr. Kathleen Kennedy, Vice President of Education and Training.Manufacturers of Pharmaceuticals, Diagnostics and Medical Devices

North Carolina Biotechnology Center

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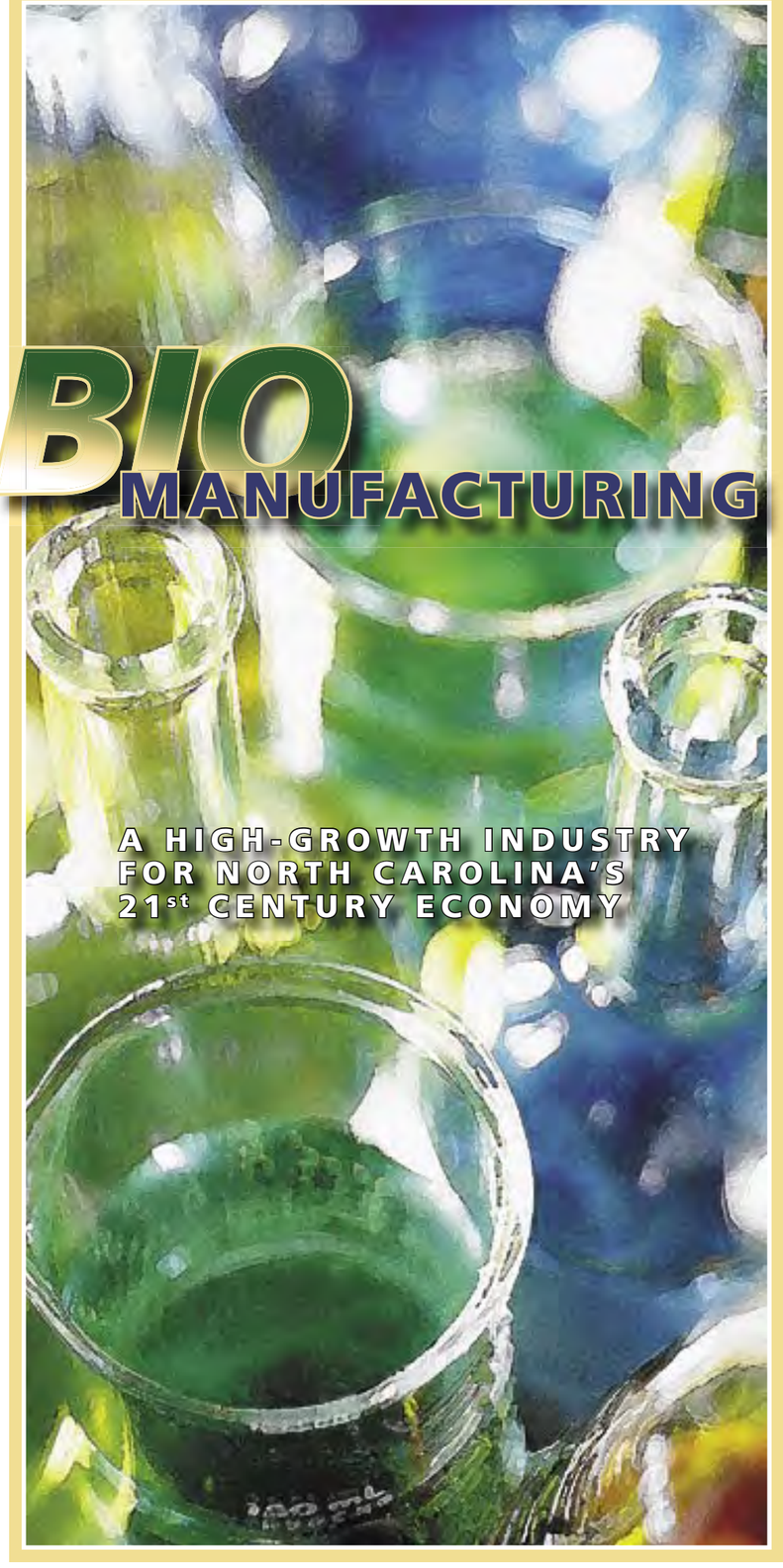


THE RISE OF BIOMANUFACTURING

Biotechnology companies throughout North Carolina are using living cells to produce medicines, vaccines, diagnostics, enzymes, amino acids, veterinary medicines and related products that improve our lives, create jobs and boost our economy. The making of these biological products is called biomanufacturing or bioprocessing.

North Carolina is a national leader in this growing industry. Fourteen companies have biomanufacturing operations in North Carolina, employing about 4,700 North Carolinians. In addition, about 15,000 other workers are employed by about two dozen companies involved in the more traditional manufacture of pharmaceuticals, diagnostics and medical devices. Added to these totals are thousands of jobs dedicated to providing goods and services in support of biomanufacturing and pharmaceutical manufacturing.

Biomanufacturing jobs pay well. Entry-level bioprocess technicians earn $25,000 to $30,000 and move up to $35,000 to $40,000 after three years and up to $50,000 after five years. The average salary for these positions in North Carolina is well above the average pay for other manufacturing jobs, which are generally declining in number. In 2002 the average annual wage in pharmaceutical manufacturing, including bioprocessing, was $68,000. The annual payroll for biomanufacturing jobs in North Carolina is estimated to be $200 million.

SEIZING THE OPPORTUNITY

As more biopharmaceuticals and other products of biotechnology move from the laboratory to the marketplace, the demand for biomanufacturing capacity is expected to increase. North Carolina is well positioned to capture a large share of this growing market. The North Carolina Biotechnology Center, in partnership with the state Department of Commerce and other organizations, is aggressively promoting the recruitment, retention and expansion of biomanufacturing companies.

In recent years two major biopharmaceutical manufacturers Ð Diosynth RTP and Biogen Idec Ð were brought to North Carolina. Diosynth, one of the world's largest contract biomanufacturers, carries out process development and drug production for biopharmaceutical companies. Biogen Idec, which operates one of the world's largest cell-culture facilities, manufactures the multiple sclerosis drug Avonex® and the psoriasis drug Amevive®. Together, these two companies have created about 1,000 new jobs for North Carolinians, and both continue to expand.

Other biomanufacturing plants with established operations in North Carolina have expanded as well. An estimated 2 million square feet of plant space is either operating or under construction in the state, with another 1 million square feet planned. Companies with recent expansions include Wyeth Vaccines, which operates one of the world's largest vaccine facilities in Sanford, and Bayer, which operates the world's largest blood fractionation plant in Clayton.

PREPARING A WORK FORCE

Job growth in biomanufacturing has averaged about 10 percent a year in North Carolina since 1990, and that trend is expected to continue if the state can provide a prepared work force. Biomanufacturing plants are complex operations that typically run 24 hours a day, seven days a week, under stringent regulation by the Food and Drug Administration. Having highly trained technicians who can operate these plants efficiently is crucial to the growth and success of biomanufacturing companies.

Adequate workforce training programs are paramount to attracting, retaining and expanding biomanufacturing companies in North Carolina. Industry, government and academia are working cooperatively to plan and implement these programs in the state.

In 2003, North Carolina committed $60 million for a statewide biomanufacturing training network to prepare workers for technical employment in bioprocessing. The initiative will address training across all the relevant scientific, technical and engineering disciplines at all levels from Certificate or Associate Degree to Ph.D. Funding for this Bioprocessing and Pharmaceutical Training Consortium came from the non-profit Golden Long-term Economic Advancement Foundation (Golden LEAF), which underwrites economic development activities using half of the state's tobacco settlement money. In addition, members of the North Carolina Biosciences Organization (NCBIO), a statewide industry trade association, pledged up to $4.5 million in equipment, professional services and other in-kind contributions to support the training program.

"We're determined that North Carolina will have the world's best-trained workforce for biomanufacturing," said Dr. Leslie Alexandre, president and CEO of the North Carolina Biotechnology Center. The Biotechnology Center surveyed the state's biomanufacturing companies to assess their employment needs, and assisted the state's community colleges, universities and biotechnology companies in partnership to push the training initiative forward.

Of the $64.5 million pledged, North Carolina State University in Raleigh will receive $36 million to build and equip a biomanufacturing training and education center. Plans call for a 91,000-square-foot plant that will provide hands-on experience in a pilot scale, Good Manufacturing Practices (GMP) environment that simulates an industrial setting.

North Carolina Central University in Durham will receive $19.1 million to build laboratory facilities and to establish relevant graduate and undergraduate degree programs. "North Carolina will gain a critical competitive advantage in attracting new biomanufacturing companies to our state," said Molly Corbett Broad, president of the 16-campus University of North Carolina.

The North Carolina Community College System will receive $9.4 million to develop training centers in support of recruiting and training workers for new and expanding biomanufacturing companies.

H. Martin Lancaster, president of the North Carolina Community College System, said the $9.4 million awarded to the system would fund training for more than 65 percent of the state's bioprocess and pharmaceutical manufacturing workers who do not have baccalaureate degrees. "Many of the people in mostly rural parts of North Carolina have depended on tobacco or the tobacco industry for their livelihood and are in critical need of new opportu-

OVERLEAF

Manufacturers of Pharmaceuticals, Diagnostics and Medical Devices

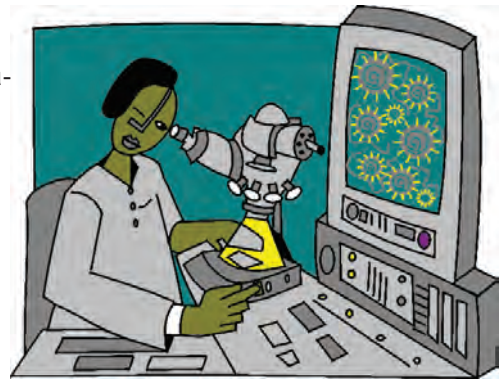
Company	Products/Services	Location
AAI	Contract pharmaceutical manufacturing services	Wilmington
Abbott Labs	Injectable solutions and drugs	Rocky Mount
Andrx	Generic pharmaceutical manufacturing	Morrisville
Alpharma USPD	Pharmaceuticals	Lincolnton
Banner Pharmacaps	Pharmaceutical gel caps	High Point
Baxter Healthcare IV Systems	Intravenous solutions	Marion
Bespak	Drug delivery devices	Apex
bioMerieux	Medical diagnostics	Durham
Cardinal Health	Contract pharmaceutical manufacturing services	Morrisville
DSM Pharmaceuticals	Drugs and fine chemicals	Greenville
Eisai Pharmatechnology	Alzheimer's drug	Research Triangle Park
Fresenius Kabi	Contract pharmaceutical manufacturing	Clayton
GBF Medical Group	Medical diagnostic kits	Greensboro
GlaxoSmithKline	Drug formulation and packaging	Zebulon
Leiner Health Products	OTC pharmaceuticals including acetaminophen	Wilson
Medtox Diagnostics	Drug testing kits	Burlington
Merck Manufacturing	Pharmaceuticals	Wilson
Microban Products	Anti-microbial polymeric additives	Huntersville
Novo Nordisk Pharmaceutical Industries	Human insulin formulation and sterile filling	Clayton
PharmaCore	Custom synthetic organic chemicals	High Point
Pisgah Labs	Pharmaceutical ingredients	Pisgah Forest
Purdue Pharmaceuticals	Pain relief, asthma medicines	Wilson
Shionogi Qualicaps	Pharmaceutical gel caps	Whitsett
TriPath Imaging (+TriPath Oncology)	Medical reagents	Burlington (Durham)
TriVirix International	Medical devices	Chapel Hill
Tyco Healthcare Mallinckrodt	Acetominophen	Raleigh
Vintage Pharmaceuticals	Pharmaceuticals	Charlotte
Wyeth Ayerst Laboratories	Antibiotics	Sanford

Careers in Genetics and the Biosciences

www.ornl.gov/hgmis/education/careers.html

The large, multidisciplinary Human Genome Project (HGP)—the effort to find all human genes and characterize a reference genome—promises to revolutionize the future so profoundly that the 21st has been dubbed the "biology century." Almost everyone will be affected by applications of information and technologies derived from the HGP era of the late 20th century. Entirely new approaches will be implemented in biological research and in the practice of medicine and agriculture. Genetic data will provide the foundation for research in many biological subdisciplines, leading to an unprecedented understanding of the inner workings of whole biological systems. The benefits of genomic research are, or soon will be, realized in such areas as forensics and identification science, ecology and environmental science, toxicology, toxic waste cleanup, and creation of new bioenergy sources and more efficient industrial processes, as well as in understanding the mysteries of evolution, anthropology, and human migration.

Among the fields that HGP research will impact are engineering, computer science, mathematics, counseling, sociology, ethics, religion, law, agriculture, education, pharmaceuticals, instrumentation, nuclear medicine, forensics, bioremediation, biofuels, and journalism. Cross-disciplinary students with solid backgrounds in science and one or more other fields such as journalism, law, business, and computer science will be needed to tackle the issues and applications arising from the HGP.



Commercialization of numerous applications in genomic science is fueling the burgeoning life sciences economic sector. Legislation and litigation increasingly will be concerned with genetics and intellectual-property issues pertaining to genetic information and technologies. Educators, the media, students, and the public need a good understanding of this "new genetics" and its implications so they can better communicate, teach, and help others make related career and personal decisions. Democratizing access to genetic science information should help maximize HGP benefits while protecting against misuse of the data. Every effort must be made to ensure that each person—regardless of race, citizenship, or national origin—enjoys the benefits of genomics research and its subsequent applications, including life improvements and excellent career possibilities. Society simultaneously must be protected from possible negative impacts such as the failure to preserve the privacy of individual genetic information.

Today, people in fields such as business, which traditionally did not require life sciences training, increasingly are finding that they need at least a working knowledge of the principles of biology and life science research and development. Presented below are some educational strategies for pursuing such cross-disciplinary careers, followed on the back page by a listing of some traditional and new bioscience career possibilities and Web sites for more information.

Preparing for a Career in the Biosciences

- ☑ Pursue a cross-disciplinary education. Biology problems are too big to be solved by only one discipline. People need science and technology basics, training in computer use and information technology, and education in bioethics to anticipate and present options for solving prickly social issues. Community and four-year colleges offer biology and related studies, including integrated science and technology programs that incorporate computer science, information technology, chemistry, biology, engineering principles, and bioethics.
- ☑ Contact your state's biotechnology industry organization, or find its careers section on the Web.
- ☑ Talk to professionals from a wide array of disciplines. Don't be shy; showing your interest will open doors.
- ☑ Gain experience in the biosciences industry via internships, volunteer work, work study, and co-op programs.
- ☑ Keep abreast of latest developments in the field by surfing the Internet for newspapers, technical magazines, and trade journals.

Government Internship Programs

- **Department of Energy Office of Science Internship Programs** (www.scied.science.doe.gov/scied/sci_ed.htm)
- **National Institutes of Health Training and Internship Opportunities** (www.training.nih.gov)
- **DOE National Laboratory Education and Internship Programs** (www-ed.fnal.gov/doe/doe_labs.html)

Sponsored by the Human Genome Program of the U.S. Department of Energy Office of Science's Office of Biological and Environmental Research. Prepared by the Human Genome Management Information System at Oak Ridge National Laboratory, Oak Ridge, Tenn. For more information, contact Betty Mansfield, mansfieldbk@ornl.gov, 865/576-6669, Fax: 865/574-9888. September 2003

Possible Career Areas in Bioscience

Note: The biotechnology industry has doubled in the past few years. In 2001, there were 726,000 U.S. jobs in the field (191,000 direct; 535,000 indirect), and more opportunities are expected in healthcare, food production, and environmental cleanup (Ernst & Young, www.bio.org). In regard to the burgeoning drug industry based on genomics, the Consulting Resources Corporation's newsletter for biotechnology professionals said, "We expect the growing family of new genomics, proteomics, and bioinformatics technologies to dominate the next decade's developments in therapeutics by greatly improving the efficiency and speed of the entire drug discovery, testing, and approval process."

Medicine

- Medical genetics, genetic counseling, genetic nursing
- Gene testing, gene therapy
- Organ transplantation, fertility, and reproduction
- Public health
- Pharmaceutical industry and suppliers
- Pharmacogenomics
- Chemical, vaccine, medicine development and production
- Database development, operation, use
- Communication, work with regulatory agencies

Agriculture and Wildlife

- Genetic modification of foods and seeds
- Biopesticide and neutriceutical development
- Wildlife management: Identification, protection of endangered species
- Authentication of consumables such as wine, caviar

Computational Biology (including bioinformatics)

- Databases, analysis, modeling, data transfer
- Supercomputing
- Mathematics, statistics, actuarial field

Engineering Disciplines

- Bioprocessing chamber, vat design and production
- Toxic waste cleanup
- Instrumentation development
- Creation of new energy sources via engineering, life science research
- Biomedical engineering

Business

- Bioscience industry investment
- Marketing and sales
- Banking

Law and Justice

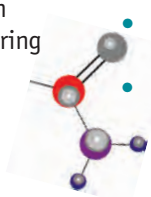
- Education
- Patent specialties
- Specialties in ethical, legal, and social issues
- Gene and paternity testing
- DNA forensics, laboratory and legal

History and Anthropology

- Use of genetics to study population-migration patterns
- Study of inheritance over evolutionary time

Military

- Soldier identification
- Pathogen identification
- Biological and chemical warfare protection
- Radiation-exposure assessment



Space Exploration

- Effects on humans
- Search for other life forms, evidence of life

Bench Science

- Sequencing of many organisms, including human
- Data analysis, computation
- Functional genomics
- Proteomics
- Human variation in health and disease
- Microbial genetics
- Environmental studies
- Education

Bioscience Communication

- Reporting, writing, editing
- Website development, maintenance
- Public relations
- Marketing
- Special events

More Information on the Web

- Careers in the Genetics Field from Genetics Societies (www.faseb.org/genetics/gsa/careers/bro-menu.htm)
- Bio (Biotechnology Industry Organization) Career Guide (www.bio.org/er/careers.asp)
- A World of Genetics Societies (www.faseb.org/genetics/)
- Biology Careers for the Next Century from Carolina Biological Supply Company (www.carolina.com/tips/97aug/tips897a.asp)
- Career Information from National Society of Genetic Counselors (www.nsgc.org/Careers/)
- Careers in Biotechnology from Access Excellence (www.accessexcellence.org/AB/CC/)
- Careers in Human Genetics from Genetic Professionals (www.kumc.edu/gec/prof/career.html)
- Careers in Microbiology from MicrobeWorld (www.microbe.org/careers/careers.asp)
- Functional Genomics Careers from *The Scientist* (www.the-scientist.com/yr2000/jul/prof_000724.html)
- Genetics: Educational Information (www.faseb.org/genetics/careers2.htm)
- Graduate Programs at School for Computational Sciences at Prince William (www.ib3.gmu.edu/programs.html)
- Guide to North American Graduate and Postgraduate Training Programs in Human Genetics (www.faseb.org/genetics/ashg/tpguide/tpg-menu.htm)
- Science Careers from *Science* (recruit.sciencemag.org/feature/advice/advice.shl)
- SciWeb Biotechnology Career Center (www.biocareer.com/index.cfm)
- Worldwide Programs in Bioinformatics and Computational Biology from The International Society for Computational Biology (www.iscb.org)

Biotechnology Careers - It's Your Choice!

Part 1 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by
GlaxoSmithKline

The Herald-Sun Newspapers-In-Education program is proud to present this informative series for our local students and teachers as well as our readers. We will explore the world of biotechnology, giving our students...our future...the opportunity to take a glimpse at some of the exciting career opportunities available in this field. With the Research Triangle Park and the incredible universities, technical and community colleges in our very own backyard, students in our local communities can complete their studies in this field, pursue a career and have the luxury of working and continuing their residence in beautiful North Carolina.

Since prehistoric times, biotechnology has flourished. From planting crops and breeding animals to fermenting fruit juices into wine or making cheese or yogurt from converted milk, the study of biotechnology has been in the works for thousands of years. Today, through biotechnology, vaccines and insulin have been developed as well as incredible strides in DNA testing.

Biotechnology is many different things to many different people. Some people think of developing new types of animals...others dream of therapeutic drugs for humans. Others envision growing crops that are more nutritious and pest-resistant to feed a rapidly growing world population. There is no one definition of biotechnology that would encompass the whole. One definition from a dictionary is "the use of living organisms or their products to modify human health and the human environment." While another definition from an encyclopedia states: "the use of microorganisms, such as bacteria or yeasts, or biological substances, such as enzymes, to perform specific industrial or manufacturing processes. Applications include the production of certain drugs, synthetic hormones, and bulk foodstuffs as well as the bioconversion of organic waste and the use of genetically altered bacteria in the cleanup of oil spills."

Many have said that the defining technology of this decade is biotechnology – as important as the silicon chip was over the last three decades! Advances in life sciences have opened up new doors for keeping people healthy, healing them when they are sick, making their food more wholesome and, generally, enhancing the quality of their lives. Just take a look at the employment opportunities in the newspaper. The pages are increasing each week as the biotechnology industry expands by leaps and bounds. Chemists, scientists, formulators, validation specialists, research engineers, clinical researchers, microbiologists, clinical project coordinators, managers for quality control analytical labs and the list continues to grow.

With around 185 biotechnology companies here in North Carolina, it is no wonder that NC ranks fourth in the nation, next only to Boston, San Francisco and San Diego. That's certainly something to be very proud of! These companies alone generate more than $3 billion in annual revenues and pay out an annual payroll of more than $925 million. And that's not all! Around one-third of NC's biotechnology companies are major multinational companies. North Carolina has experienced a growth rate in the biotechnology industry of 15% a year. It is estimated that by the year 2025, more than 125,000 North Carolinians will work in the biotechnology field.

As you follow this series, you will hear from local folks who work in the biotech industry and get a glimpse at different positions within this ever-growing field. This series should help answer some of your questions and direct you to additional resources. Are you curious? Do you enjoy figuring out how things work? Have you always dreamed of creating a new medicine that would cure the common cold? Are you concerned about the foods we eat? Do you have a love for math? This series might open up a whole new world for you!

Activity:

1. Find an article in today's **Herald-Sun** that features a breakthrough in the biotechnology industry. Look for an article that discusses a health concern or problem and brainstorm with your classmates about the various ways you could solve the problem.

2. Find the classified section in today's **Herald-Sun** and look through the employment opportunities for the biotechnology industry. Read several ads that peak your interest and make notes regarding the qualifications for those particular jobs. Check the newspaper weekly and continue to add to your notes.

Be sure to visit www.rtp.org for a complete listing of the biotechnology and biopharmaceutical companies located in the Research Triangle Park. You can also visit www.ncbiotech.org for the North Carolina Biotechnology Center's website for valuable information.

For more information about Newspapers-In-Education, contact Jackie Pierce at 419-6539.

Biotechnology Careers - It's Your Choice!

Part 2 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight for Newspapers-In-Education

Sponsored by
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Environmental Health and Safety Specialist

The Occupational Safety and Health Administration (OSHA) has strict regulations for industrial safety. An environmental health and safety specialist (EHSS) is responsible for developing, implementing and monitoring industrial safety programs.

It is a huge responsibility to protect your co-workers, but a most rewarding one. It is a huge responsibility to help protect the environment – but the satisfaction is enormous. If you are willing to use reference materials, find answers, network with other professionals and have a respect for the environment, people and safety... this might just be the job for you. You will be responsible for wearing many different hats and will gain respect and appreciation from your peers. Be prepared for a lifelong learning experience and a profession that brings different challenges each day.

An EHSS inspects the facilities and equipment as well as the working conditions to identify and correct potential hazards. Depending on the type of industry that employs the EHSS, responsibilities range from hazardous materials to safety clothing and devices. Some typical duties would include:

- investigate reports of unsafe conditions and industrial incidents
- inventory hazardous materials, waste and substances handled and stored
- conduct tests and field investigations using precision instruments to obtain data to determine sources and methods of controlling hazardous substances in air, water and soil
- collect samples of potentially hazardous materials for analysis
- maintain complete computer documentation
- compile, analyze and interpret data to assess regulatory compliance
- prepare technical reports with observations, analysis of contaminants and recommendations for control and correction of hazards
- develop and distribute accident investigation reports
- maintain liaison with technical professionals and various governmental agencies to ensure local environmental quality standards, industrial practices and new developments

The EHSS must be able to reason, understand instructions, make judgments and possess verbal, numeric and spatial aptitudes. Analytical and problem-solving abilities with a good memory, the ability to concentrate along with patience would be highly advantageous qualities in this field. Depending on the job level, an EHSS may also be required to conduct training programs in hazardous waste collection, disposal and radiation safety regulations.

For an entry-level position in this field, a Bachelor of Science Degree or equivalent from an accredited college or university is required. For different industries, the requirements change and may include a Bachelor's Degree in biology, microbiology, cellular biology, infectious diseases or a Master's Degree in biosafety or public health.

While still in high school, if you are truly interested in pursuing a career in this field, try to secure an internship with one of our local industries. You will gain incredible experience in the field and be able to add to your "pro and con" list, which will assist you in making your career decision. In addition, it is most important to develop leadership skills through professional society activities and training. This is a must for your résumé as well as for any application for a college or university.

Activities:

1. Check out the classified section in today's **Herald-Sun**. Find job opportunities for an EHSS and make a list of the requirements for this position as listed in the newspaper. Continue to add to your list using Sunday's edition of the **The Herald-Sun**. Cut out this article and attach your list to it. Make a folder and repeat this activity for each part of the series. You will have an invaluable resource for career choices in the biotechnology field.
2. You are an EHSS. Your school is your employer. What are your safety concerns? What steps would you take to correct and/or improve a potential or real safety hazard?

Check It Out!

Using **The Herald-Sun**, find articles relating to environmental health and safety. Share your articles with your classmates and hold a discussion concerning the most pressing issues. Who agrees and who disagrees? What issues you can add to those discussed in the newspaper?

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Biotechnology Careers - It's Your Choice!

Part 3 of 16 parts featured each Monday and Wednesday, October 6 – December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Clinical Research Associate (CRA)

Clinical research is a rapidly expanding field and creates exciting opportunities for the CRA. Research studies have a major impact on health care, by developing new medications and testing new treatment devices and methods. Pharmaceutical, biotechnology and medical device firms employ CRAs as well as academic health centers, government agencies and contract research organizations.

A clinical research associate sets up, monitors and completes clinical trials. What is a clinical trial? A clinical trial is a scientific study of the effects, risks, efficacy and benefits of a medicinal product. Trials may be performed on healthy humans to study safety, therapeutic studies of efficacy and safety in a small number of relevant patients, larger short- and long-term studies, pharmacokinetics and pharmacodynamics. During and after the launch of a new product, further studies are conducted to monitor safety and side effects in large-scale use.

The responsibilities of a CRA vary significantly from company to company. Some CRAs are involved in the entire trial process, from the idea stage through to the final report while others are involved in only the collection of data once the trial has been set up.

Some of the responsibilities of a CRA could involve:

- Developing/writing trial protocols
- designing the data collection forms (known as case record forms or CRFs)
- coordinating Ethics Committee and Regulatory Authority applications and approvals (Ethics Committees safeguard the rights, safety and well-being of all trial subjects and Regulatory Authorities oversee research and the marketing of new and existing drugs)
- setting up study centers
- briefing doctors, consultants or investigators on conducting the trial
- locating and assessing the facilities at a study center for suitability
- monitoring the trial throughout its duration
- verifying the data entered on the CRFs to be consistent with patient clinical notes
- filing and collation of trial documentation and reports
- drug accountability
- discussing results with a medical statistician (the person responsible for writing technical trial reports)
- archiving study documentation

Some of the skills that a potential employer would be looking for are:

- the ability to develop and deliver presentations (good writing and oral skills)
- the ability to make evaluative judgments
- the ability to independently develop novel concepts and techniques (creativity)
- knowledge of federal and state regulations and guidelines pertaining to the conduct of clinical trials on human subjects
- knowledge of current and developing trends and standards in clinical trial monitoring.

If this sounds like a career for you, it would certainly be to your advantage to seek a position as an intern within this field. Minimum educational requirements include a Bachelor's degree in Basic or Health Sciences. Most companies will require 2-5 years of experience in the field or in a related area. You must have knowledge of FDA regulatory requirements, be familiar with standard concepts, practices and procedures and demonstrate flexibility, as you will be performing a variety of tasks.

There are several levels that a Clinical Research Associate can reach, however, typical earning potential for a CRA is in the range of $50,000 to $65,000 per year. Advancement to management is certainly reachable for a seasoned CRA.

It's Only Words!

pharmacokinetics – the study of the bodily absorption, distribution, metabolism, and excretion of drugs; the characteristic interactions of a drug and the body in terms of its absorption, distribution, metabolism, and excretion.

pharmacodynamics – a branch of pharmacology dealing with the reactions between drugs and living systems.

efficacy – the power to produce an effect.

protocol – an original draft, minute, or record of a document or transaction; a detailed plan of a scientific or medical experiment, treatment or procedure

Activities:

1. Don't forget to add this feature along with employment opportunities listed in **The Herald-Sun** to your notebook!

2. Create a research project for your classroom. As an example – what effects do colder temperatures have on your classmates? Or, how many of your classmates have an adverse reaction to changes in seasons (such as allergies, dry skin, etc.)?

Did You Know?

Biotechnology started a long, long time ago. In 1750 B.C. – the Sumerians brewed beer, the Greeks practiced crop rotation to maximize soil fertility in 250 B.C. and insecticide was used in China (made from powdered chrysanthemums) in 100 A.D.

The Herald-Sun Newspapers-In-Education

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Biotechnology Careers - It's Your Choice!

Part 4 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Toxicologist

What is toxicology? Toxicology is the scientific identification and study of the effects of harmful chemicals, biological materials and radiation on living systems and the environment and how they can be avoided or minimized. Toxicological research and testing helps us to live safely and to derive benefit from natural and synthetic substances while avoiding harm.

No substance is risk-free. All chemicals can cause harm at some level of exposure. Exposure to a specific small amount of any substance will have no detectable impact and is considered safe. Some doses, such as in medicines, have beneficial effects. Substances are considered toxic when exposure is increased. As an example, oxygen is essential to life and part of the air we breathe. But, when given at high concentrations, it can cause lung and eye damage – thus turning a safe compound into a toxic one.

A toxicologist plans and carries out laboratory and field studies to identify, monitor and evaluate the impact of toxic materials and radiation on the health of humans and animals and the status of the environment. Some examples could include the safety of new chemicals in pharmaceutical applications, industrial chemicals, agricultural products, foodstuffs, toiletries and other consumer products.

Typical responsibilities may include:

- researching scientific literature
- writing scientific papers
- making hazard assessments
- isolating, identifying and quantifying toxic substances or radiation and determining possible harmful effects on biological materials, animals, plants or ecosystems
- planning and carrying out laboratory or field experiments
- analyzing and evaluating statistical data
- carrying out risk analyses
- advising on the safe handling of toxic substances and radiation in production or in the event of an accident

Positions are typically available in this field at several different levels... trainee, intermediate, experienced and advanced. Below is an example of some of the knowledge required at the advanced level:

- general principles, practices and procedures of toxicology, biology and chemistry
- hazard assessment procedures
- relationships between the toxicological, physical and chemical properties of chemicals
- risk assessment procedures and applications
- laws and regulations pertaining to the control and management of chemicals
- biological and chemical degradation processes
- general concepts pertaining to the environmental fate of chemicals
- procedures and techniques utilized in correction or mitigating toxic substance problems
- application of statistical methods to research data in toxicology, chemistry and biology
- computer technology applications
- ability to write in a concise, easily understandable manner

Toxicologists usually work in an environment where they are exposed to hazardous materials. You may be employed in an office, laboratory or even work outdoors. Occasionally, you would be required to work in an environment that involves exposure to unpleasant and noxious fumes and odors.

A master's degree in toxicology or a physical, biological or environmental science is most often required. Experience of practical laboratory work is essential and certain industries will require animal handling experience as well. Your organizational skills and ability to coordinate work of others and set priorities are beneficial attributes.

Industries that often employ toxicologists are: consumer product, pharmaceutical, chemical, and contract research, academic, petrochemical, state, local and governmental agencies. You may also find career opportunities as a consultant.

Vocabulary:

quantify - to determine, express, or measure the quantity of

Factoid!

Dogs are treated with heartworm medication because the risk of death from heartworms far outweighs the risk of toxicity of the medication.

Chemotherapeutic agents are used to destroy cancerous cells even though they may damage healthy cells in the process.

Find It!

Using today's edition of **The Herald-Sun**, find an article about a new medicine or an environmental hazard. What are the pros and cons of each? What further research would you like to see take place? Hold a classroom discussion.

Do not forget to check the classifieds to add job descriptions to your Biotech Careers notebook!

The Herald-Sun Newspapers-In-Education

For more information about Newspapers-In-Education, contact Jackie Pierce at 419-6539.

Biotechnology Careers - It's Your Choice!

Part 5 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Documentation Coordinator

A documentation coordinator is responsible for providing clerical and administrative support to a company's documentation system requirements. Although responsibilities of the documentation coordinator may vary depending on the size of the company and the products the company develops, generally, typical duties would include:

- audit all documentation manuals to ensure accurate and up-to-date information
- make sure manuals are available to all appropriate personnel
- track, file and retrieve master documents
- develop distribution schedules

Most documentation coordinators work in companies that manufacture pharmaceutical products. The FDA regulates this industry to ensure that drugs are manufactured properly and formulated correctly. Many of these documents must be kept or filed with the government to obtain federal approval of a product. It is therefore essential that they are kept up-to-date and accurate.

In order to qualify for a position as a documentation coordinator you must be familiar with computer databases, copiers, document imaging equipment and scanners. Record keeping and technical writing skills are required as well as knowledge of Standard Operating Procedures (SOPs) and Good Manufacturing Practices (GMPs). You will need a high school diploma to be considered for an entry-level position with some companies requiring an Associate's degree for more advanced positions. Internships in this field are strongly encouraged. Computer knowledge is a must as is accuracy and attention to detail.

Many biotechnology companies promote from within. If you take advantage of the education benefits provided by the company and just by gaining work experience within the company, advancement opportunities can be very rewarding. Most documentation coordinators earn an annual income of $24,000 to $40,000. Advancement might include a position as a technical writer or documentation specialist.

Documentation Specialist

Are you interested in having the opportunity to change the way that life sciences deploy technology in pursuit of research discoveries? Do your skills include experience with standard computer software such as Word, Excel and Assess? Do you possess strong organizational skills and attention to details? Are you self-motivated? Do you have diverse options, cutting-edge solutions and creative ideas? Are you innovative and do you want to become successful? These are all questions that might be asked during your interview for a position as a documentation specialist.

A documentation specialist is responsible for revising, distributing and maintaining all compliance documents including standard operating procedures, specifications and procedures, protocols, reports and other miscellaneous documents. Some biotech industries might require you to gather, analyze and compose technical information. You may also be asked to conduct research and ensure the use of proper technical terminology or translate technical information into clear, readable documents to be used by non-technical personnel.

Educational requirements usually include an Associate's degree. With a Bachelor's degree, normally two years experience is required. As noted in previous parts of this series, it is to your advantage to have experience as an intern.

Did You Know?

Most biotech employers recruit by using some of the following methods: employment agencies, in-house promotion or transfer, internet job listings, internships, newspaper advertisements, private employment agencies, professional publications and meetings, referrals from colleges or schools, referrals from current employees, walk-in applicants and word of mouth.

Check It Out!

Be sure to visit www.vgcc.edu to find out information about Vance-Granville Community College's Franklin County Campus Biotechnology Center. Their special course - BioWork, is a highly successful course that trains process technicians to work in North Carolina's fast-growing biotechnology industry.

Activity:

1. Don't forget to look in The Herald-Sun for employment opportunities in this field and include these classified ads to your Biotech notebook.

2. Discuss with your classmates which subjects would be most important to excel in to be qualified for the positions reviewed in this feature.

The Herald-Sun Newspapers-In-Education

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Biotechnology Careers - It's Your Choice!

Part 6 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Research Associate

If you have a love of science, excel in math, have excellent written and oral communication skills and possess the ability to identify and troubleshoot problems, then a career as a research associate might be right for you. You must also be organized, detail oriented, capable of working independently as well as have good observation skills. Technical skills might include:

- analyzing and evaluating technical data
- biotechnology laboratory procedures
- computer
- knowledge of life sciences and chemistry
- knowledge of SOPs, GMPs and GLPs
- ability to plan and carry out research

As directed by a scientist, the research associate is responsible for designing the experiments and protocols used in a research project. There are a multitude of areas of scientific study including sequencing DNA from a human, animal, plant or other sources, recombining DNA from different organisms to create a new or improved product such as a drug or even a better crop plant. The research associate may work in research and testing that supports clinical trials of new drugs or developing processes to manufacture these new products in a safe, economical and efficient manner.

The research associate is required to make detailed observations of procedures and experiments. Additional responsibilities might be:

- interpreting the data using scientific knowledge and statistical analysis
- create reports detailing your findings
- operate and maintain laboratory instruments
- follow all health and safety regulations
- make sure technicians and assistants follow health and safety regulations
- (university setting) find funding for projects by writing and applying for grants
- (senior level research associate) be in charge of large project or laboratory

This is a fascinating career. Imagine being asked to make presentations at scientific conferences or write articles for journals! The research associate might also be responsible for projects that can lead to a product, which can be patented.

A general understanding of research methods and applications is very important in this job. Potential employers usually look for hands-on lab experience, strong problem-solving skills and the ability to identify and troubleshoot practical problems. As with most careers today, computer skills are essential.

Entry-level positions require at least a bachelor's degree in biology, molecular biology, biochemistry, chemistry or a related field. Laboratory experience may be required... usually 1-3 years. Some industries require a master's degree; others will allow you to start your employment at an entry-level position such as a laboratory technician with an associate degree. By getting extensive laboratory experience, you can work your way up to entry level research assistant, earn a bachelor's degree and be advanced to research associate. There are many companies that will assist you with the cost of furthering your education for this purpose.

Almost every community college offers a general science program that includes biology, chemistry and other life science courses that prepare students for transfer to a four-year college. If this is a field you are interested in, you might start your education at a community college and transfer to a four-year college or university to receive your bachelor's degree.

Working your way up to a research associate is also monetarily rewarding. With a master's degree, your average annual income should be around $70,000 to $75,000. With a bachelor's degree, your annual salary could range from $30,000 to $45,000. Keep in mind that the pay scale for research associates varies considerably depending on experience, type of employer and your educational background. You will more than likely work a regular 40-hour week although it would not be unusual for you to be required to work overtime while tending an ongoing experiment.

Many biotechnology industries employ the research associate – agricultural products, food companies, pharmaceuticals products, industrial products and environmental companies. Some educational institutions, research institutions and government agencies also seek research associates.

Activities:

1. Don't forget to look in The Herald-Sun for employment opportunities in this field. Include the classified ads for a research associate in your Biotech notebook. Using one of the ads you have found, practice writing a letter of introduction to the company that seeks a research associate.
2. Review the educational requirements above. In your Biotech notebook, make a list of the different areas that you would need to concentrate on in order to be suitable for a position as a research associate.
3. Visit www.ncbiotech.org and find out what they have to say about this fascinating career.

The Herald-Sun Newspapers-In-Education

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Biotechnology Careers - It's Your Choice!

Part 7 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Quality Control Technician

This particular field has several different job titles: quality auditor, quality control associate, quality control inspector or quality control technical specialist. All positions require similar personal skills, basic skills, technical skills as well as educational background.

In the biotechnology industry, a quality control technician is responsible for inspecting and checking the raw materials and products of biotechnology to make sure that they meet required levels of quality. Although most jobs are in biotechnology companies that manufacture pharmaceutical products, this job is also available in a variety of manufacturing and laboratory settings. Typical responsibilities would include:

- data collection and analysis of results
- maintaining accurate records of the results of inspections
- examine raw materials and equipment components from suppliers
- test goods during the manufacturing process
- test finished products
- assure that materials and components meet required specifications

A career in quality control is an excellent choice for people who are good at research and investigation. Employers are looking for people that possess:

- analytical skills
- ability to evaluate technical data
- computer skills
- knowledge of life sciences and chemistry
- knowledge of SOPs (Standard Operating Procedures)
- knowledge of GMPs (Good Manufacturing Practices)
- problem solving and critical thinking skills
- record keeping skills

Personal and basic skills might include:

- detail oriented
- excellent observation skills
- ability to work independently AND the ability to work as part of a team
- advanced math
- excellent written and oral communications skills

Good laboratory skills and manufacturing or laboratory experience is a plus when applying for this position. Most employers prefer applicants to have a bachelor's degree in chemistry, biochemistry or biotechnology. In addition, one to two years of experience in a pharmaceutical or biotechnology laboratory is usually desired. Some employers may hire people with an associate degree along with manufacturing and laboratory experience. There is also the possibility of going into this field at an entry level with just a high school diploma and two to four years experience in manufacturing at a biotechnology company.

Career advancement for quality control technicians with a bachelor's degree and related experience can be promoted to a quality control analyst and other supervisory positions. For those quality control technicians who have an associate degree or a high school diploma - taking advantage of the education benefits that most biotechnology companies offer can assist them in obtaining their degree while gaining experience in the quality control area.

For any position that requires a bachelor's degree, you can always begin your education at a community college and transfer to a four-year college to obtain your bachelor's degree. Almost all community colleges offer courses in computer science, biology, microbiology and chemistry. They also offer courses in technical writing which is an important skill to possess if you intend on getting past an entry-level position in quality control.

Quality control technicians usually work a standard 40-hour workweek. However, during production, quality control technicians may need to be present 24 hours a day, seven days a week. This is where shift work is common. Do keep in mind that night shift and weekend work often earn a higher rate of pay.

Depending on your level of expertise and experience, the salary range for this position is $30,000 to $50,000 per year. Most biotechnology companies offer excellent benefit packages for full time workers. Some of the benefits may be:

- vacation
- holidays
- medical and dental benefits
- sick leave
- profit sharing plans
- retirement plans
- life insurance
- tuition reimbursement for furthering your education
- work release for education in related field
- flexible hours

ACTIVITIES:

1. Look in the classified section of The Herald-Sun and find job opportunities in this field. Clip out the ads and put them in your Biotech Careers notebook for reference.
2. Discuss with your classmates the pros and cons of attending a community college prior to furthering your education at a university or college.
3. Check out www.rtp.org for a complete listing of biotechnology companies located in our area. Another helpful source is www.ncbiotech.org where you find similar listings.

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Biotechnology Careers - It's Your Choice!

Part 8 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Manufacturing Technician

Manufacturing technicians are the people who actually make the products that are sold by biotechnology companies. A manufacturing technician can work in many different industries. Any biotechnology industry that makes a product for sale needs to hire manufacturing technicians. These companies make food products, pharmaceuticals, agricultural products, industrial chemicals and more.

In pharmaceutical companies, they produce drugs and testing kits for various types of diseases. Instrument supply companies would need to hire manufacturing technicians to manufacture equipment, supplies and biological materials. Industrial companies would require the assistance of manufacturing technicians to produce enzymes that are used to manufacture products such as laundry detergents. Think about the food industry... using biotechnology, they manufacture products ranging from corn syrup to food additives to soy sauce. All these industries use biotechnology, just in different ways to produce different products!

The typical working environment for a manufacturing technician would normally be in a large-scale manufacturing plant. There, huge containers are used that hold thousands of liters of material for production or, in pilot plants, small amounts of a substance for testing, further research and clinical trials. In order to preserve sterile conditions, the manufacturing technician may be required to wear special clothing. More than likely, they will be subject to loud noises from filtration systems and perhaps low temperatures.

In biotechnology manufacturing, there are many steps. The manufacturing technician may work on one or several of these steps. For instance...

- preparing materials and equipment required for production
- sterilizing equipment
- collecting materials used to grow the bacteria, yeast or other cells
- add nutrients for cell growth
- grow cells in fermentor
- monitor equipment during production
- purify product from the cells that have been grown
- perform maintenance on equipment
- maintain facilities

Some industries might require the manufacturing technician to ensure that batches of the product contain the proper ingredients and quantities. As listed above, monitoring equipment during production would be essential in the pharmaceutical field. A drug must be produced exactly as the FDA approves the process in order to be legally sold. If something should go wrong, this would be costly to the company in supplies, lost time and the lost cost of the product.

In order to be considered for a position as a manufacturing technician, you must possess the following technical, personal and basic skills:

- be able to read and interpret technical materials
- have good problem-solving and critical-thinking skills
- manufacturing skills
- knowledge of SOPs and GMPs (defined in Part 7)
- computer skills
- familiarization with biotechnology laboratory procedures
- possess organizational skills
- be capable of working as part of a team
- have the stamina to work under pressure
- be detail-oriented
- possess advanced math skills
- have excellent written and oral communication skills

Entry requirements for manufacturing technician positions vary. Some employers will hire technicians with a high school diploma along with 2-4 years of experience as a manufacturing assistant. Other employers require college coursework or even an associate degree in biotechnology or related science major.

Once employed as a manufacturing technician – don't think that you are in a dead-end position! You can be promoted to a manufacturing associate, lead technician and gain a supervisory positions within the company. With additional experience, you may be moved to quality control or quality assurance. If you go for your bachelor's degree and have experience as a manufacturing technician – you could move on to become a research associate.

Depending on your education level, you can make from $27,000 to $40,00 at entry-level status or up to $70,000 per year with advanced experience. Most often you will be required to work a 40-hour work week. Shift work would be required if the particular company that you are employed with is open 24 hours per day.

Activities:

1. Look in the classified section of **The Herald-Sun** and find job opportunities in this field. Clip out the ads and put them in your Biotech Careers notebook for reference.
2. Discuss with classmates possible internships that you could apply for next summer to assist you in gaining the required experience to become a manufacturing technician.
3. Make a list of the skills you already feel you possess that would assist you in applying for a position in this field.

The Herald-Sun Newspapers-In-Education

For more information about Newspapers-In-Education, contact Jackie Pierce at 419-6539.

Biotechnology Careers - It's Your Choice!

Part 9 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Bioinformatics Programmer

Scientists and researchers create enormous amounts of information. Bioinformatics programmers design computer programs that scientists use to gather, store, and study information about genes, proteins and molecules in living things. Scientists can then analyze the genes or proteins and learn how they function. Most often a bioinformatics programmer assists scientists in the following fields:

- genomics (which analyzes information about genes) or
- proteomics (which uses computers to predict what proteins will be created by genes, how proteins fold into shape and how they interact)

This information is used to study the causes of disease and to try to find drugs or treatments for disease. It is also useful in identifying molecules that might be developed into drugs.

The two main occupations within bioinformatics are programmers and systems engineers. The programmers write the software and design databases. A very strong science background is required in order to design systems that scientists can understand and use to retrieve information. The databases designed by the programmers are used to merge information from several sources. Programmers often work as a team with scientists and other programmers.

Bioinformatics systems engineers manage the computer systems once they are designed by the programmers. Again, a strong science background is required along with computer skills. Systems engineers also install, test, support and maintain computer systems. They may be required to train customers who use their programs.

Companies that design bioinformatics software or systems that are sold to researchers employ the bioinformatics programmer and system engineer. Both the programmer and systems engineer may also find employment with scientists at private companies, research institutes and universities. Biotechnology companies, especially those specializing in genomics, employ bioinformatics programmers and systems engineers.

You can look for positions available in this field using the Internet and by reading the newspaper. Positions may be advertised under several different job titles – bioinformatics programmer, bioinformatics scientist, bioinformatics analyst, bioinformatics software engineer or informatics developer.

In order to qualify for a position in this field, the following technical, personal and basic skills may be required:

- technical writing
- read and interpret technical materials
- knowledge of life science and chemistry
- problem solving
- critical thinking
- advanced computer skills
- analyze technical data
- evaluate technical data
- detail oriented
- work as a team and independently
- excellent organizational skills
- advanced math
- excellent written and oral communication skills

A bachelor's degree in computer science, molecular biology, genetics, chemistry or a related field is generally required. One to two years of experience in a bioinformatics, genomics or a molecular biology laboratory is also required. If you possess a bioinformatics degree that combines biological science and computer science – you are a perfect candidate for a position in this field.

Knowledge is also essential in specialized molecular biology computer programs, databased and programming languages such as HTML, Perl and JAVA. Operating systems such as UNIX and relational database such as Oracle are often used and your skills should include experience with both. The specific computer programs that are required vary by job duties and the employer.

Bioinformaticists can advance to a scientist position that would require supervision of other staff and management of entire projects. Company management positions are also a higher level attained in this field as well as those bioinformaticists that have actually created a product and started their own company to develop and sell the product.

Entry level annual income starts at around $45,000 - $55,000. With just three years of experience, you can expect your annual income to reach as high as $80,000.

Activities:

1. Look through **The Herald-Sun** and cut out job opportunities you find in this field. Place the ads in your Biotech Careers notebook for easy reference.
2. If this is a field that you might be interested in pursuing, make a list of required skills that you already possess and another list of those skills that you will need to acquire.
3. Prepare a letter of inquiry to several local companies about the availability of internships. Share your letter with your classmates. Hold a classroom discussion and critique the different letters to improve their quality.
4. Practice writing a cover letter to go with your resume, using a company that you found in **The Herald-Sun** classifieds.

The Herald-Sun Newspapers-In-Education

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Biotechnology Careers - It's Your Choice!

Part 10 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Laboratory Assistant

The laboratory assistant is an excellent position in which to start a biotechnology career. This is an entry-level position in research and development for a person with college level courses in biology and chemistry. There are many job opportunities for those with good laboratory skills. A laboratory assistant position is a perfect place to start with your eye on advancement to a laboratory technician or research associate after earning a bachelor's or master's degree. Should you seek a Ph.D., this career path could lead to a staff scientist position or other positions within the biotechnology industry.

Further advancement in this particular field could lead to specialization in a particular phase of research such as media preparation or fermentation. Laboratory assistants may also have the opportunity to move into the manufacturing area of a company as a manufacturing assistant or technician. With additional experience, a lab assistant may choose to move into the quality control and assurance fields.

Laboratory assistants help researchers in the more routine and simple aspects of a project. They prepare materials used in experiments and offer assistance in discovering and testing new drugs, improving food crops and creating new industrial products. Under the direct supervision of research staff, assistants may write experimental reports or summaries. One of the most important responsibilities of the laboratory assistant is making detailed measurements and observations using a variety of scientific equipment and keeping accurate records of all work performed.

Typical additional responsibilities may include:

- weighing and measuring chemicals
- preparing media (the mixture of chemicals needed to grow cells)
- work with cells of animals, plants, bacteria and viruses
- prepare solutions and buffers for experiments
- maintain laboratory equipment
- keep the laboratory stocked with supplies
- clean and sterilize glassware
- maintain cleanliness of laboratory

As experience is gained, laboratory assistants will often be required to add to their list of responsibilities. With experience and additional education, some laboratory assistants are specialized and trained to assist in more complex procedures such as:

- preparing tissue cultures
- protein purification
- gel electrophoresis
- grow bacteria
- plasmid preparation
- preparation of protein extracts
- use advanced equipment and techniques to conduct their research

Depending on the type of biotech industry, educational requirements vary. Usually, you would be required to have at least an associate degree with a specialty in biotechnology or a biological science. Math and chemical courses are essential. Many companies will hire a laboratory assistant with a specialized certificate in biotechnology from a community college.

Hands-on laboratory skills are extremely important in getting this position. But perhaps some of the most important skills that a laboratory assistant needs are record keeping, work area organization, weighing and pipetting. All of these skills can be gained from laboratory skills classes, internships or previous experience working in a lab.

Technical, personal and basic skills may include:

- knowledge of biotechnology laboratory procedures
- computer skills
- knowledge of Standard Operating Procedures (SOPs)
- knowledge of General Laboratory Procedures (GLPs)
- excellent observation and organizational skills
- capable of working as part of a team
- excellent written and oral communication

Most laboratory assistants work in laboratory or manufacturing environments. Since they work with a variety of chemicals, some hazardous, attention to safety is extremely important. Sometimes laboratory assistants are required to work in clean rooms where the temperature is cold and therefore need to wear special clothing for comfort and to maintain a sterile workplace.

A laboratory assistant can expect to make $21,000 to $30,000 per year, again with the potential of advancement in this field and increases in annual income. Full-time and part-time positions are available at most companies and some positions may require working evenings and weekends.

To gain experience in this field in addition to completing the educational requirements, you might contact colleges, universities and research institutes. Often, they will set aside part-time jobs for students. Many biotechnology companies have internship programs – paid and unpaid – for students at the lab assistant level. Usually, these positions are available during the school year and full-time in the summer.

When looking for an opening in this field, be sure to check out employment opportunities listed as assistant media preparation technician, laboratory technical assistant, laboratory technician and media assistant. Various job titles are used by different industries.

Activities:

1. Look in the classified section of **The Herald-Sun** and find job opportunities in this field. Clip out the ads and put them in your Biotech Careers notebook for reference.

2. Check out the Internet! Look for Web sites of local biotechnology industries to find out if internship positions are available. A good place to start is www.ncbiotech.org.

3. If you completed the educational requirements, gained the necessary lab experience and pursued a career in this field, would you be able to afford to live in your own apartment? Using the low end of the annual pay scale mentioned above, prepare a budget.

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Biotechnology Careers - It's Your Choice!

Part 11 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Instrumentation/Calibration Technician

This position is an excellent choice for those who have an interest in both electronics and biotechnology and also enjoy solving problems. Manufacturing plants, research and development departments in biotechnology, food processing, chemical plants or pollution control agencies all employ instrumentation/calibration technicians. Technicians who have a particular interest in the biomedical area can seek employment in major medical centers and universities with large research departments.

An instrumentation/calibration technician plays a very important role in the biotechnology industry. They work in all areas of biotechnology, installing, inspecting, maintaining and repairing the specialized equipment used in research and manufacturing. Some typical duties might include:

- calibrating instruments
- perform validation studies to ensure equipment is operating properly
- use calculators and computers
- use testing devices and laboratory equipment
- use electronic and mechanical instruments
- comprehend and use engineering handbooks and reference materials
- maintain inventory
- maintain maintenance logs
- install specialized biotechnology instruments
- provide training for proper procedures to use while running equipment

Entry-level annual wages range from $25,000 to $35,000 while an experienced instrumentation/calibration technician can earn upwards of $55,000 annually. Unless you are employed with a manufacturing company that operates 24 hours per day, you can expect to work a typical Monday through Friday 40-hour week. Some field technicians have the opportunity for additional overtime by being on call to repair machinery.

Educational requirements vary. Most employers will require completion of an associate degree in engineering or electronics/instrument technology. Electronic theory, electrical circuitry and digital and microprocessor computer knowledge is essential. Knowledge of life science is a plus. Other employers may accept experience in lieu of a degree. Check out your local community colleges to get started.

Technical, personal and basic skills usually required may include the following:

- computer skills
- the ability to troubleshoot
- knowledge of solid record keeping
- interpretation of technical materials
- knowledge of electronics
- advanced math
- good written and oral communication skills
- mechanical aptitude
- the ability to work well under pressure

Positions for an instrumentation/calibration technician may also be listed under the following categories:

- validation technician
- instrumentation technician
- engineering technician
- electronics engineering technician
- calibration specialist
- calibration lab technician

Activities:

Biotechnology companies offer excellent benefit packages. When pursuing a possible life-long career, benefits are to be considered part of your salary. A position may be offered with a base annual salary but you must remember you will need to add the worth of your benefits to that figure in order to come up with the actual value of your annual salary.

1. Look in the classified section of The Herald-Sun. See if you can find a job opportunity for this particular job or another job in the biotechnology industry that you may be interested in pursuing. Write down the annual salary. If the company offers health insurance and you are required to pay one half and they provide the balance of the cost, their contribution to your health insurance cost would need to be considered part of your annual income. Does the company provide you with paid holidays and vacation? If so, this too would need to be considered as part of your annual income. Are you allowed personal and sick leave? Again, this is part of your annual income.

2. Exercise: Write down an annual salary that you feel you could make with the proper education and experience. Divide the annual salary by 52 weeks to find out how much money you would make each week. Take that figure and divide by 40 hours to figure what you would make per hour. (All of these figures do not take into consideration taxes taken out of your salary).

3. Now you have a figure to work with – an hourly wage and weekly wage. So, if you are allowed two weeks vacation each year, you can figure out the value of your vacation. If you have a certain number of paid holidays per year, you can figure out the value of your holidays. Complete this exercise with each benefit that you would be offered by a potential employer.

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Biotechnology Careers - It's Your Choice!

Part 12 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

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Technical Service Representative (TSR)

One of the main priorities of a technical service representative is to help other people solve technical problems. A TSR helps customers use the products they have purchased (equipment, pharmaceuticals, or biological products such as DNA, viruses or bacteria). Most of the assistance provided by a technical service representative is over the telephone where the TSR must be able to understand the problem and find a solution. Some problems may arise that would require the TSR to visit the customer's work site to perform further troubleshooting.

The TSR may also provide assistance to potential customers by helping them understand how to order a product and ensure that the customer is ordering the correct product. Once a product is purchased, a technical service representative might visit a company to show the staff how to use the product.

The technical service representative is usually expected to attend meetings on product updates and is continuously trained for new products. The TSR must be able to keep accurate documentation of all service provided to customers as well as bring to the attention of a supervisor repetitive problems.

To give you some idea of how a typical classified ad for this position might read and what some companies are looking for, read the following. "ABC CORPORATION is looking for a full time, dependable individual to perform installations and training for the ABC Autostainer and reagents, working on-site at ABC's customers' locations. To assure customer satisfaction, the candidate will assist the laboratories in the development of applications of chemistries on the Autostainer and be available for frontline troubleshooting and problem solving, including light repairs on ABC Autostainers, in labs using ABC products. The candidate will also assist the sales organization in technical presentations and demonstrations for ABC customers. There will be extensive travel over five or more south central states. Previous experience in histology and automated immunohistochemistry required."

A technical service representative position may also be listed in the classifieds or Internet under job titles such as: customer service representative, customer support engineer, service technician or technical representative. Employers hiring entry-level technical service representatives usually require someone with a strong science background, good customer service skills and excellent problem solving skills. A bachelor's degree in a life science field such as biology, molecular biology, biochemistry or biotechnology is preferred. Some employers will accept an associate degree in a life science, as well as one or two years of experience.

The following skills are essential if you are interesting in becoming a technical service representative:

- advanced math
- detail oriented
- excellent written and oral communication skills
- customer service skills
- telephone skills
- work both as team and independently
- work well under pressure
- analyze and evaluate technical data
- knowledge of biotechnology laboratory procedures
- excellent computer skills
- knowledge of life sciences and chemistry
- good problem solving and critical thinking skills
- ability to read and interpret technical materials
- knowledge of SOPs, GMPs and GLPs

This is an excellent career path for someone who has a science background but is not interested in pursuing laboratory work. Promotion opportunities might include management and supervisory roles. In a senior level position, responsibilities would be more diverse including development of service strategies and training new technical service representatives. A TSR also works closely with sales and marketing and may acquire the necessary sales skills to move into a position on the sales and marketing team.

You can find positions available with all biotechnology companies that have a product to sell or maintain - including pharmaceuticals, agriculture, instrumentation and supplies, biotechnology research services, environmental and forensics.

Annual salary varies according to experience. You can expect the range to be from $30,000 to $50,000.

Activity:

Find the classified ads in The Herald-Sun. Read through the ads and note how many companies require excellent written and communication skills. Discuss with your classmates the steps you would need to take to improve these skills.

Did You Know?

To enhance your skills and gain and advantage when applying for any position in the biotechnology field - try some of these tips!

- obtain internships
- go to seminars
- do research with a professor
- join professional organizations
- keep informed with new biotechnological innovations
- complete training courses working with laboratory equipment and procedures
- work as a lab assistant
- develop work habits that are systematic, precise and patient
- acquire a background in computer science
- Good Luck!

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Biotechnology Careers - It's Your Choice!

Part 13 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Scientist

A scientist position is often listed under several different job titles: biochemist, associate scientist, bacteriologist, biologist, biophysicist, chemist, forensic examiner, microbiologist, pathologist, research scientist and staff scientist. Depending on the company at which you are employed, your job responsibilities will vary. Scientists are idea people that work in the research and development area with new biotechnology products. Biotechnology uses many different areas of science.

In biochemistry, scientists study chemical compositions of living things, complex chemical combinations, reactions involved in metabolism, reproduction, growth and heredity. Scientists in this field use the genetic code of organisms to find out which genes control different traits of living things. They recombine DNA from different organisms to create new life forms. These are used to create products such as drugs, vaccines, medicines, treatments for cancer, AIDS and many other diseases.

Some scientists actually develop products to clean up hazardous waste or work on developing new crops that resist disease. Typical responsibilities, again depending on the type of company that you are working for, and might include:

- devise experiments
- write protocols for conducting experiments
- develop techniques and equipment used in research
- perform laboratory experiments
- write reports and articles for scientific journals
- make presentations at professional meetings/seminars

Biological scientists are in demand in the private industry, universities, research institutes and government laboratories. In applied research, biological scientists work on product development directed towards projects that can be sold and fit the emphasis of a firm's products and goals.

Molecular scientists, or biologists study biophysics and biochemistry. They are involved in the molecular building blocks of life...such as, DNA, RNA, amino acids and proteins. Microbiologists study the growth and characteristics of microscopic organisms (bacteria, algae and fungi) and use biotechnology to advance knowledge of cell reproductions and human disease.

Related technical, personal and basic skills are:

- computer skills
- knowledge of SOPs, GMPs, GLPs
- technical writing
- knowledge of life sciences and chemistry
- evaluate and analyze technical data
- detail oriented
- work well under pressure
- work independently
- excellent observation skills
- advanced math
- excellent written and oral communication

Normal working environment would consist of a laboratory. The scientist will often be required to work with dangerous organisms or toxic substances and must adhere to strict safety procedures to avoid contamination. Their workweek normally consists of the regular 40 hours, Monday through Friday.

Although a senior scientist can make upwards of $100,000 annually, it takes many years of experience to reach this six-figure salary. Starting pay usually ranges from $60,000 to $80,000 per year. A huge perk is the bonuses that many biotechnology companies pay to a scientist who discovers or develops a product that can be patented. The bonus could actually double a scientist' salary.

Some scientists are able to develop products and start their own companies...many move into managerial or administrative positions after spending many years performing research. Scientists can also advance to a consulting position with many businesses or governmental agencies. Colleges, universities, private research institutes or government facilities also employ scientists as professors. Scientists that work at universities more than likely will be required to write grants and obtain funding for projects they pursue.

A Ph.D. is required for a scientist position in a scientific discipline. Several years' experience as a laboratory technician or research associate can also lead to a scientist position. If pursuing employment with a college or university, several years in a post doctoral position is usually required.

Activities:

1. Using The Herald-Sun, find an article about a scientific breakthrough. What makes this finding so significant? Share your article with your classmates and brainstorm how you would carry this breakthrough one step further - a spin-off perhaps?

2. Make a list of the scientific discoveries that have come to past over the last decade. How have they changed life, as we know it?

3. Look in the classified ads section of The Herald-Sun and find employment opportunities in this field. Cut them out and ad to your Biotech Careers notebook for future reference.

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Biotechnology Careers - It's Your Choice!

Part 14 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Greenhouse Technician

What makes fruit ripen? Why do some plants thrive in moist conditions while others grow their very best during drought conditions? Why do some plants love the shade while others only bloom and grow in the full sun? How do tomatoes accumulate large amounts of lycopene (an important antioxidant that may inhibit degenerative diseases such as cancer and heart disease)? Can other fruits produce lycopene? These and other questions like them can be answered through plant research.

If you love to work outdoors, don't mind getting a little dirt under your fingernails, and enjoy working with plants... becoming a greenhouse technician might just be the job for you! Agricultural biotechnology companies, agricultural research stations associated with colleges and universities, as well as food-related biotechnology companies all employ greenhouse technicians.

This position can be found in the classified section of the newspaper, the Internet or possibly posted at a college or university under the following job titles:

- greenhouse assistant
- plant tissue culture technician
- seed production technician
- soil media technician

Greenhouse technicians are responsible for technical aspects of growing and caring for plants that have been created through genetic engineering. Plants are usually grown to produce seeds for additional research including testing the results of recombining DNA of plants.

Typical tasks would likely include:

- planting seeds
- applying pesticides
- watering and weeding the plant beds
- nurturing root cuttings
- observing plant growth
- checking plants for signs of disease
- monitoring growth progress of plants
- entering data in computer database
- interpreting data collected
- reporting to research and development scientists and technicians
- creating new plants from fully grown plants (plant tissue cultures)

In the biotechnology industry, a greenhouse technician is usually required to be certified by the state in order to apply pesticides. The technician must be extremely careful with the plants they work with as many of the plants are unique or special in other ways and will required extra care for specialized experiments.

Greenhouse technicians usually work outdoors or in a greenhouse. Sometimes a company will have a large building with small indoor greenhouses called growth chambers. In the growth chamber, the technician will be required to control the level of light, temperature, humidity, water, soil and nutrients that each plant receives. This will enable the greenhouse technician to make detailed records of conditions and plant growth.

A 40-hour work week is normal for a greenhouse technician and part time positions are readily available. Shift work is common, as plants require special care every day of the week. Some of the qualifications that a potential employer would look for are:

- computer skills
- plant propagation skills
- record keeping skills
- knowledge of SOPs, GMPs and GLPs
- knowledge of life sciences
- manual dexterity
- observation skills
- detail oriented
- basic math
- excellent written and oral communication skills

At an entry level, a greenhouse technician would need a bachelor's degree in biology, botany or another life science. Some employers will hire people with an associate degree with classes in plant science, crop science or botany. Experience as a greenhouse worker is always beneficial.

Annual wages range from $25,000 to $45,000. Many companies promote from within and advancement opportunities may include:

- plant science associate (supervises greenhouse workers and technicians)
- greenhouse coordinator or manager (the employee in charge of all greenhouse operations such as maintenance, space allocation and installation of new equipment)

Activities:

1. Don't forget to check the classified section of **The Herald-Sun** to find positions available in this field. Cut out the ads and place them in your Biotech Careers notebook for future reference.
2. Look in **The Herald-Sun** to see if you can find an article about a scientific breakthrough involving plants. What impact does this breakthrough have on our world today?
3. Have a classroom discussion about the different companies that you could work with to gain experience with plants.

It's Only Words!

genetic – relating to or determined by the origin, development, or causal antecedents of something

botany – branch of biology dealing with plant life

recombinant DNA – genetically engineered DNA prepared in vitro by cutting up DNA molecules and splicing together specific DNA fragments usually from more than one species of organism

The Herald-Sun
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Biotechnology Careers - It's Your Choice!

Part 15 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sales Representative

If you are outgoing, enjoy people and travel, have a science background and a sales aptitude, then a sales representative position with a biotechnology company could be a terrific career choice. Sales representatives work in many different industries - basically, for any company that has a product or service to sell. In the biotechnology field, you can work in pharmaceuticals, agriculture, instrumentation and supplies, environmental and forensic areas.

Sales representatives have face-to-face contact with prospective customers as well as speaking to them on the telephone. In this position, a sales rep might be responsible for making a presentation about the company's products to a large assembly of potential customers. The sales representative would also be required to explain the product to the customer and assist them in purchasing the correct product for their specific needs.

With so many different companies to select from, a sales representative might sell pharmaceuticals to doctors, hospitals and HMOs or sell hazardous waste clean-up systems to assist with cleaning up toxic spills. Researchers require special equipment and farmers require specialized seeds and pesticides. These too are items that would require the services of a sales representative in order to get these products to the end users.

Some sales representatives might be required to demonstrate a product and answer technical questions about its use. Often, once the product is delivered, the sales representative would need to make a return visit to the customer's facility to assure that the product is working correctly and that the employees are fully trained in its operation. In this case, the sales representative would work hand in hand with the technical sales representatives. The technical sales representatives would be the technical experts.

Requirements for a sales representative position may include:

- knowledge of life sciences and chemistry
- ability to read and interpret technical materials
- computer skills
- valid driver's license for extensive travel
- organizational skills
- sales skills
- telephone skills
- basic math
- excellent written and oral communication skills
- customer service skills
- detail oriented
- ability to work as part of a team as well as independently

A bachelor's degree in a life science field or other scientific discipline is usually required. Some employers may accept a bachelor's degree in business or marketing although most companies prefer two or more years of related experience such as laboratory technician or instrumentation technician.

Entry-level sales representatives can expect to make from $45,000 to $60,000 annually. With gained experience, an annual salary of $80,000 is not out of the questions, especially with a good commission schedule and bonuses based on amount of sales. Since most sales representatives are assigned certain areas or regions, as their areas and client base grow - naturally their salary will grow. As mentioned in previous features about Biotechnology Careers, the biotechnology industry offers excellent benefit packages that increase the worth of your annual salary. Advancement opportunities would include sales manager, sales analyst, product manager or district manager.

To find a position in this field, you can look in the classified section of The Herald-Sun, look on the Internet or check for job postings at colleges and universities. A great way to gain experience for this particular position is through internships offered at many biotechnology companies. General sales experience is extremely important to help you sharpen your interpersonal skills. It would certainly be beneficial to you if you were to seek a summer position in a sales environment (food, clothing, equipment, etc.).

Positions for a sales representative can also be listed under the following titles:

- account manager
- scientific sales
- sales specialist
- sales coordinator
- manufacturer's agent
- project management assistant

Activities:

1. Look in the classified section of The Herald-Sun and find positions available for a sales representative in the biotechnology field. Cut the ads out and place them in your Biotech Careers notebook.
2. Create or select a product you would like to sell. Make a presentation to your classroom. Ask your teacher and classmates to critique your presentation.

Survey It!

Poll your classmates to see how many have worked in a sales environment. Discuss the pros and cons to help you determine whether this is a career you wish to pursue.

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Biotechnology Careers - It's Your Choice!

Part 1 of 16 parts featured each Monday and Wednesday, October 6 - December 1

Written by Bonnie McKnight

Sponsored by GlaxoSmithKline

Who Is Doing What In Biotechnology?

Biotechnology is alive and well in all countries of the world. Many feel we have only hit the tip of the iceberg and we will continue to explore the depths for years to come.

According to the Canadian Biotechnology Industry Report 2003, Canada claims their biotechnology industry is a "rich source of innovation with 417 core biotechnology companies..." Ernst & Young reports that Canada ranks second behind the United States in the number of biotech companies. Most of their companies focus on therapeutics and diagnostic product development. They are considered the "new kids on the block" as 80% of their core biotechnology companies were created less than six years ago. With over 69% of their biotechnology companies involved in health research, it is safe to say we can tell where Canada's priorities lie.

In 1997, France Biotech was created as the industry representative for French biotechnology companies. As a non-profit association, it interacts with the government, the pharmaceutical industry, research institutes, the media and financial communities. Over the last six years it has educated the public on the scientific, medical and economic impact of biotechnology, obtained new legislation to accelerate the growth of biotechnology in France as well as promoting networking of French research laboratories and biotechnology companies on an international scale. Since its creation, biotechnology in France now ranks fourth worldwide in the number of biotechnology patents granted annually. It has experienced a large increase in the number of biotech firms (250) and now employs more full-time researchers than any other country in Europe except Germany.

Germany is the largest biotech market in Europe with approximately 400 companies. GPC Biotech located in Munich, Germany (with research facilities in Massachusetts and New Jersey) was honored this year with First Prize at the Annual European Bio Technica Award for Excellence in Biotech Business. GPC is dedicated to discovering and developing new anti-cancer drugs through innovative discovery technologies and development approaches.

In Australia, most biotech industries concentrate their efforts on human health. As reported in 2000 by Ernst & Young, there were approximately 190 biotech companies in operation across Australia. Australia has more biotechnology companies per capita and per gross domestic product than the United States.

With over over 20 biotechnology companies and more than 40 marketed products, the United Kingdom is one the world leaders in biotechnology. Britain boasts many accomplishments in the field of biotechnology such as: key player in the world-wide project of sequencing the 30,000 genes of the human genome, responsible for key breakthroughs in health research including DNA fingerprinting and development of needle-free injections.

What Has Biotechnology Done for Us Lately?

As reported by the Biotechnology Industry Organization...some of the breakthroughs during the period from 1990 to 2002 were:

- first experimental gene therapy treatment successfully performed on a 4-year-old suffering from an immune disorder
- first insect-protected corn
- scientists unveil a technique for testing embryos in vitro for genetic abnormalities
- first breast cancer gene is discovered
- first baboon-to-human bone marrow transplant performed on an AIDS patient
- discovery of a gene associated with Parkinson's disease provides new avenue of research into the cause and potential treatment
- animal cloning
- first conviction using genetic fingerprinting
- discovery that hereditary colon cancer is caused by defective DNA repair gene
- sequencing of the genomes of the parasite that causes malaria and the species of mosquito that transmits the parasite was completed
- biotech crops were grown on 145 million acres in 16 different countries
- successful results were reported for a vaccine against cervical cancer - the first demonstration of a preventative vaccine for a type of cancer

More than 325 million people have been helped by more than 155 different biotechnology drugs and vaccines. Of all the biotech medicines on the market, 70% were approved by the FDA within the last six years! Currently there are more than 370 biotech drug products and vaccines in clinical trials that target more than 200 different diseases such as various cancers, Alzheimer's disease, heart disease, diabetes, multiple sclerosis, AIDS and arthritis.

Biotech foods such as papaya, soybeans and corn are now being enjoyed by the consumer. Hundreds of agricultural products have been discovered to improve our food supply. Caustic chemicals are no longer used to clean up hazardous waste. The list of accomplishments would be endless. Biotechnology is a career path that will also lead you on a endless journey - a journey of discovery.

Did You Know?

- There are almost 1500 biotechnology companies in the United States. Revenues have increased from $8 billion in the year 1992 to $34.8 billion as of 2001!
- 191,000 people are currently employed by the U. S. biotechnology industry.

The Herald-Sun Newspapers-In-Education

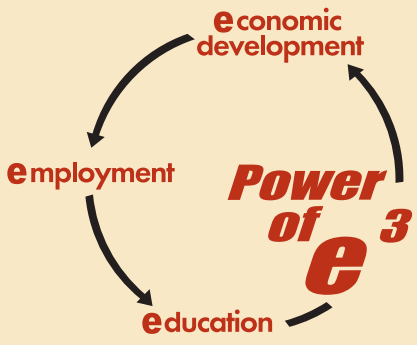
For more information about Newspapers-In-Education, contact Jackie Pierce at 419-6539.

High-Growth INDUSTRY PROFILE

Industry Snapshot

Growth Pattern

- The biotechnology industry, which is evolving, can be defined as the use of biological processes (particularly cellular and molecular) to solve problems and/or make useful products. The biotechnology industry includes firms that use cells and biological molecules for applications in medicine, agriculture, and environmental management. (Source: "The Emerging BioEconomy," New Economy Strategies, Inc.)
- The biotechnology industry more than tripled in size since 1992, with revenues increasing from $8 billion in 1992 to $27.6 billion in 2001. (Source: Biotechnology Industry Organization)
- Drug manufacturing, agricultural services, and health services, all of which are involved with biotechnology, are projected to add more than 3 million new jobs between 2000 and 2010. (Source: U.S. Bureau of Labor Statistics)
- From 1992 to 2001, the number of employees in the industry more than doubled, from 79,000 to 191,000. (Source: Ernst and Young, annual biotechnology industry reports)
- A particular area of growth that is well-funded is counter-bioterrorism—working to find means of detecting and stopping bio-threats such as anthrax, smallpox, SARS, and other potentially fatal diseases. Funding is used by universities, corporations, and other researchers to develop antidotes, immunizations, biosensors, and related technology. (Source: Hoovers Online)



Occupational Outlook

Prospects are for faster-than-average job growth for biological and medical scientists over the 2000-2010 period.

Wage and salary jobs in drug manufacturing are expected to increase by about 24% from 2000 to 2010, making this one of the faster growing manufacturing industries.

Between 2000 and 2010, the number of employed biological technicians is expected to grow by 26%, while the number of employed biological scientists is expected to grow by 21%. (Source: U.S. Bureau of Labor Statistics)

Biotech-Related Occupations	2000-2010 % Projected Growth	Median Annual Earnings	Postsecondary Education & Training
Biological technicians	26.4%	$31,540	Associate degree
Biological scientists	21.0%	$49,239	Doctor degree
Medical scientists	26.5%	$57,196	Doctor degree
Chemists	19.1%	$50,080	Bachelor's degree
Agricultural and food science technicians	15.2%	$27,080	Associate degree
Chemical technicians	15.0%	$35,450	Associate degree
Agricultural and food scientists	8.8%	$52,160	Bachelor's degree

Drug Manufacturing Industry, Total Employment & Top 10 Occupations, 2001		
Occupation Title	Total Employment	% of Total
Total biotechnology industry	324,740	100.0
Packaging and filling machine operators and tenders	29,090	8.96
Team assemblers	24,460	7.53
Chemists	14,620	4.50
Maintenance and repair workers, general	9,920	3.05
Mixing and blending machine setters, operators, and tenders	9,470	2.92
Inspectors, testers, sorters, samplers, and weighers	9,340	2.88
First-line supervisors/managers of production and operating workers	9,280	2.86
Medical scientists, except epidemiologists	6,980	2.15
Biological technicians	6,630	2.04
Chemical technicians	6,420	1.98

Research, Development, and Testing Services Industry Total Employment & Top 10 Occupations, 2001		
Occupation Title	Total Employment	% of Total
Total biotechnology industry	669,700	100.0
Interviewers, except eligibility and loan	43,390	6.48
Executive secretaries and administrative assistants	20,670	3.09
Chemists	19,820	2.96
General and operations managers	18,860	2.82
Biological technicians	16,770	2.50
Medical scientists, except epidemiologists	16,130	2.41
Office clerks, general	15,070	2.25
Secretaries, except legal, medical, and executive	13,910	2.08
Chemical technicians	13,740	2.05
Survey researchers	10,760	1.61

This is not a comprehensive list of occupations. Please refer to the U.S. Bureau of Labor Statistics at the links below for more biotechnology occupational information.

Drug Manufacturing Industry
www.bls.gov/oes/2001/oesi3_283.htm
Research, Development, and Testing Services Industry
www.bls.gov/oes/2001/oesi3_873.htm

Types of Jobs Created

Skill Sets:

(Source: U.S. Bureau of Labor Statistics)

- Job opportunities are expected to be best for qualified graduates of science technician training programs or applied science technology programs.
- Many employers prefer applicants who have at least two years of specialized training or an associate degree in applied science or science-related technology. Because employers' preferences vary, however, some science technicians need a bachelor's degree in chemistry or biology, or have taken several science and math courses at four-year colleges.
- Persons interested in careers as science technicians should take as many high school science and math courses as possible. Science courses taken beyond high school, in an associate or bachelor's program, should be laboratory-oriented, with an emphasis on bench skills.
- Prospective science technicians can acquire good career preparation through two-year formal training programs that combine the teaching of scientific principles and theory with practical hands-on application in a laboratory setting that includes up-to-date equipment.

Workforce Issues

The overarching workforce issues are recruitment, education, and training. The following insights on some of these workforce issues were gathered directly from senior executives within the biotechnology industry:

- The industry needs to define the occupational characteristics outside of the Ph.D. level for individuals interested in entering the field. Those interested in entering the field must also recognize that employers seek employees who possess soft skills as well as technical skills.
- There is an increasing need to update the secondary and postsecondary science and math curricula to meet the skill requirements identified by the biotechnology industry.
- The public is not aware of the necessary skill sets and competencies needed to prepare for the diverse career opportunities available within the biotechnology industry.

What is the High-Growth Job Training Initiative?

The High-Growth Job Training Initiative is a strategic effort to improve the public workforce system's responsiveness to the needs of the labor market so that the workforce investment system can become demand-driven.

The Initiative is specifically designed to build collaborations among employers, industry leaders, business associations, educators, trainers, the community and technical college system, and the public workforce system.

The purpose of these partnerships is to support models that operationally demonstrate how a demand-driven workforce system can more efficiently serve the workforce needs of business while also effectively help workers find good jobs at good wages.

High-Growth Job Training Initiative

In our efforts to meet the workforce demands of the 21st century economy, the U.S. Department of Labor's Employment and Training Administration (ETA) is conducting forums with various targeted high-growth industries. The Executive Forums are opportunities for senior executives and human capital experts to communicate the critical workforce issues facing their industry.

ETA conducted the first Biotechnology Industry Executive Forum in Newark, Delaware, on May 16, 2003. The individuals attending the Forum represented 12 biotechnology organizations. Executives from the following biotechnology organizations attended the first Executive Forum:

- DuPont Agriculture & Nutrition
- CB Research & Development, Inc.
- Incyte Pharmaceuticals
- Discovery Genomics
- AstraZeneca Pharmaceuticals, L.P.
- Fraunhofer USA Center for Molecular BioTechnology
- Christiana Care Health Systems
- Xechem, Inc.
- New Economy Strategies
- Pharmacopeia, Inc.
- W.L. Gore & Associates
- KamTek, Inc.

Next Steps

ETA is addressing the workforce issues of the biotechnology industry from a national perspective by conducting Executive Forums with different sectors of the biotechnology industry to gather relevant information from informed groups in a disciplined manner.

These forums will provide ETA and the public workforce system with the opportunity to gain further understanding of the overall critical workforce needs of the industry. After meeting with industry leaders, ETA will develop and solidify strategic alliances with business, education, and workforce leaders who are proactively focused on the workforce issues confronting the biotechnology industry and engage them in developing innovative approaches to addressing their needs.

ETA is partnering with employers and education providers to develop and model skills training solutions nationally that can be replicated and sustained throughout the state and local public workforce system. These approaches will help ensure that workers have the right skills for the right jobs at the right time.

The ETA In Action

Forsyth Technical Community College "Textiles to Technology": Developing a Biotechnology Workforce for North Carolina's Western Piedmont

Challenge

North Carolina's Piedmont Triad Region has experienced a severe economic downturn due to the decline of its traditional furniture, tobacco, and textile industries, which once supported economic growth and job development in the region. Large numbers of dislocated workers in the area lack the skills they need in order to transition into careers in the region's emerging biotechnology industry.

Addressing the Challenge

Forsyth Technical Community College (Forsyth Tech) will use its recent $754,146 grant from the ETA and $150,828 in leveraged contributions from business and education partners to implement a biotechnology associate degree training program for the region's dislocated workers. Forsyth Tech will retrain workers who have been dislocated from declining industries so that they are qualified for employment in the emerging biotechnology field. The Forsyth Tech curriculum will focus on training laboratory technicians in biotechnology and related pharmaceutical occupations.

Sustainable Impact

Forsyth Tech's pilot biotechnology training curriculum was developed in partnership with area biotechnology and pharmaceutical firms and has the backing of companies in these sectors. This demand-driven focus on training and skills development, in combination with leveraged support from key education, industry association, and community partners, will ensure that Forsyth Tech's program succeeds in the Piedmont Triad Region and serves as a replicable model for other communities experiencing similar economic and industry transitions.

National Programs

Apprenticeship

The apprenticeship system is working closely with the High-Growth Job Training Initiative to assist the biotechnology industry in identifying and defining its technical workforce needs. Many of those workforce needs and skills are embedded in sectors of the manufacturing and health care industries that are currently using registered apprenticeship.

Additional Resources

Online Tools

Career One-Stop
(www.CareerOneStop.org)
The Career One-Stop is a resource for businesses and job seekers. It contains links to America's Job Bank, America's Service Locator, and America's Career InfoNet.

www.careervoyages.gov
www.doleta.gov
www.high-growth.org
www.onetcenter.org

Other Tools

Toll-Free Help Line
1-877-US2-JOBS (1-877-872-5627)
1-877-889-5627 (TTY)
The Toll-Free Help Line provides up-to-date information about the full range of workforce services for workers and businesses as well as answers to employment and training questions.

Contact the BRG

For more information on the activities and services of the ETA's Business Relations Group (BRG), please contact:

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