

## Bakersfield College

<b>Course Number &amp; Title:</b>	Biol 30 Introduction to Biotechnology & Cell Physiology
<b>Units &amp; Course Hours:</b>	4 units, 108 hours
<b>Weekly Hours:</b>	3 lecture, 3 laboratory
<b>Number of Weeks:</b>	18
<b>Repeatability:</b>	0
<b>Credit/Applicability:</b>	Baccalaureate Degree Applicable AA/AS Degree Applicable Certificate Applicable
<b>Disciplines:</b>	Biological Sciences, Agriculture, Chemistry
<b>TOPS No.:</b>	0430.00
<b>Comments:</b>	This course is part of an approved program Biotechnology & Biomedical Technology

### Course Description

An introductory biotechnology course covering basic terminology, techniques, history, and future of biotechnology industries. An overview of important biological molecules, the cell, genetic and bioengineering mechanisms, gene expression and manipulations, basic laboratory skills, safety, and industrial techniques. Field trips will be required. Prerequisites: Chem 1A, 2A or 15 **and** Biol 10, Biol 11, Biol 20 or Biol 3A with a grade of C or better. Hours: (108) 3 lecture/3 lab. Offered: S. CCS: Occupational Education. Transferable: CSU and private colleges.

### Text & Supplemental Education Materials

The Cell—A Molecular Approach by Geoffrey Cooper, ASM Press/Sinauer Associates, Inc., 1997. *Note:* Any current cellular physiology and biotechnology text and relevant lab book is appropriate and left to the discretion of the instructor. The texts are updated regularly and should be at the introductory level.

### Course Goals and Objectives

Following completion of this course students will be able to:

1. Use and understand basic biotechnical terminology.
2. With accuracy and reproducibility apply the metric system to volume, mass and linear measurements and prepare solutions of various concentrations.
  - Objective A:** The students will become familiar with various laboratory tools for measurement such as Eppendorf pipettes, volumetric flasks, graduated cylinders, beakers, metric scales, etc.
  - Objective B:** The students will prepare solutions of varying concentrations and dilutions.
3. Explain lab safety procedures, GLPs (good lab practices), waste treatment and biohazard considerations.
  - Objective A:** The students will read and explain a typical MSDS.
  - Objective B:** The students will pass a safety test.
  - Objective C:** The students will describe waste streams in the lab.

- Objective D:** The student will perform scientific documentation of all lab experiments.
4. Describe the significance of the structure and function of biologically active molecules.
    - Objective A:** The student will develop a basic understanding of the components and function of proteins, nucleic acids, carbohydrates and lipids
    - Objective B:** Methods of separation and isolation of proteins and nucleic acids will be demonstrated. Chemical assays and record keeping are an integral part.
    - Objective C:** Students will apply their knowledge to identification of an unknown molecule.
  5. Explain modern concepts of cell structure and function.
    - Objective A:** The student will develop an understanding of the plant and animal cell.
    - Objective B:** The student will locate anatomical structures in a cell and identify physiological functions necessary to sustain the life of the cell.
    - Objective C:** The students will acquire a basic understanding of the cell membrane and apply this information through investigational studies of the membrane.
    - Objective D:** The student will know and perform aseptic technique and learn the use of an autoclave and incinerator as methods of controlling cell reproduction.
  6. Discuss the historical perspectives of DNA and applications to genetic engineering.
    - Objective A:** Understand the chronological development of DNA knowledge.
    - Objective B:** Review experimental empirical data leading up to the elucidation of DNA structure.
    - Objective C:** Describe the discovery of bioengineering tools and their application.
    - Objective D:** Develop a basic understanding of gene expression, manipulation and DNA cloning.
  7. Display competencies as described by the SCANS documents.
    - Objective A:** Identify, organize, plan and allocate resources for experiments.
    - Objective B:** Work as a member of a team of diverse students, exercising leadership, negotiating and teaching others new skills.
    - Objective C:** The student will be required to acquire, evaluate, interpret and communicate information.
    - Objective D:** The student will understand, monitor and use various technical and organizationally complex systems.
    - Objective E:** The student will select, apply, maintain and troubleshoot a variety of technical equipment as it applies to biotechnology and computers.

### Course Content

- The Science of Biotechnology 1 week
- Safety, Biohazards, and Good Lab Practices 1 week
- Using the Metric System 1 week
- Preparation of Solutions 2 weeks
- Cell Structure and Function 2 weeks
- Chemistry of Cells 2 weeks
- Fundamentals of Molecular Biology 2 weeks
- Flow of Genetic Information 3 weeks
- Cell Regulation—Factors in Gene Regulation 2 weeks
- Industrial and Agricultural Applications 2 weeks

## **Attachments**

1. Example of a critical thinking problem for this course.
2. Outside reading sample.
3. Content review worksheet and evaluation for biology and chemistry prerequisites.
4. Equivalent lower division courses for transfer:
  - Pepperdine                      Biol 108—Genes and Human Affairs
  - UCLA                              Biol 9—Intro to Cell & Molecular Biology
  - UCSD                              BILD 1—Introduction to the Cell
  - UCD                                Biol 10—Introduction to Human Heredity
  - CSU Northridge              Biol 107,107L—Biological Principles II & Lab

## Biol 30 Critical Thinking

Critical Thinking Exercises for Starr's Biology: Concepts & Applications, 2<sup>nd</sup> ed.

1. Radioisotopes can be used to identify the pathway or destination of a substance that has been introduced into an organism. Which of the following assumption is most important for such an experiment?
  - A. Each radioisotope decays spontaneously into a different isotope.
  - B. Molecules that contain radioactive atoms are not changed into different compounds
  - C. Ionizing radiation damages cells and can kill them.
  - D. Instruments can detect the presence and location of radioisotopes.
  - E. Cells act upon molecules that contain radioactive atoms in exactly the same way they act upon molecules that do not contain radioactive atoms.

**ANALYSIS: Give a complete analysis concerning the assumptions & why they are appropriate or incorrect.**

2. A section of animal tissue was treated with a chemical that stained nucleic acid. Upon examination under the microscope the nuclei were seen to be heavily stained. Which of the following would be the best conclusion you could draw from this observation?
  - A. Nucleic acid is a polymer.
  - B. Polymers are found in all parts of the cell.
  - C. The nuclei contain nucleic acid.
  - D. These cells contain more nucleic acid than most other cells.
  - E. Nucleic acid is composed of nucleotide monomers.

**ANALYSIS: Give a complete analysis concerning the conclusions above and why they are appropriate or incorrect.**

3. A flask contains a solution of polymer. A solution of enzyme is added to the flask. A student makes the hypothesis that the polymer is protein and that the enzyme catalyzes the hydrolysis of protein. What hypothesis could the student make as to the contents of the flask following treatment with the enzyme? What components could he/she test for?

# Bacteria Break the Antibiotic Bank

by John Maynard Smith

*Drug-resistant genes are leaping across species boundaries.*

The brief era in which such infectious diseases as pneumonia, tuberculosis, and gonorrhoea could be effectively controlled by antibiotics may be nearing its end. Strains of disease-causing bacteria resistant to penicillin and other antibiotics have rapidly evolved, and—even more unsettling—such resistance can often be passed from one type of bacterium to another.

Penicillin, for example, kills bacteria by binding irreversibly to enzymes (called penicillin binding proteins, or PBPs for short) that normally help bacteria manufacture cell walls. The penicillin bond puts the PBP enzymes out of action and thus prevents bacteria from synthesizing new cell walls. As a result, the bacteria die.

But bacteria can evolve resistance to penicillin in two ways. The first and most common method is for bacteria to arm themselves with  $\beta$ -lactamase, an enzyme that breaks down penicillin before it can do any damage. The gene that codes for  $\beta$ -lactamase is not actually part of the bacterial chromosome; it is carried on an accessory piece of DNA known as a plasmid. Plasmids, which are self-replicating circles of DNA, can travel from one bacterium to another, and from one kind of bacterium to another, across very wide taxonomic boundaries.

Almost all bacteria carry plasmids, which confer a wide variety of properties on their hosts, including the ability to metabolize unusual nutrients, to resist heavy metal ions and toxic substances, and to resist attack by viruses. Plasmids that encode for  $\beta$ -lactamase probably originated a long time ago. Penicillin has been around for many millions of years, although its clinical use is new. It is manufactured by some soil fungi, presumably because it helps them compete with soil bacteria. Most likely, a plasmid that permitted the production of  $\beta$ -lactamase first evolved in a soil bacterium, and it and

its host then proliferated because of the protection it conferred.

During the last fifty years, as a result of the widespread use of antibiotics, plasmids with the gene for  $\beta$ -lactamase have been incorporated in most of the bacteria that live in humans. Acquiring plasmids that carry the genes they need is one way bacteria can evolve and become adapted to changed circumstances—in this case the increased exposure to penicillin. This is similar to the process of symbiosis, whereby higher organisms sometimes acquire new abilities by linking up with a partner, such as a bacterium, fungus, or alga—that has the necessary genes.

For example, the roots of peas and beans have bacteria that provide them with nitrogen in usable form, and heathers have fungi associated with their roots that enable them to live on nutrient-poor, acidic soils. Similar symbioses enable termites to digest wood and some animals to live in deep-sea vents. The difference between these examples and plasmids is that the symbionts of higher animals and plants were once capable of a free-living existence, and often still are, whereas plasmids are mere circles of DNA that could never have multiplied outside the cell. They apparently originated as pieces of bacterial chromosomes.

Most bacteria have evolved the ability to resist penicillin by acquiring a partner, a plasmid, that has the necessary gene. Plasmids that confer resistance to many other antibiotics are also now widespread. Some plasmids even carry genes that enable them to confer resistance to more than one antibiotic.

Other bacteria have followed a different route to penicillin resistance: they have changed their PBP enzymes so that penicillin will no longer bind to them. This is true of *Neisseria*, a genus that includes the

causative agents of gonorrhea and of some cases of bacterial meningitis.

The gene coding for the PBP2 enzyme (the most important of the penicillin binding proteins) was analyzed for several penicillin-sensitive strains of *Neisseria meningitidis* and for a number of resistant strains. The sensitive strains were all very similar to one another, and their differences had little effect on the sequence of amino acids (protein building blocks) in the PBP2 enzyme. The genes belonging to the resistant strains, differed significantly. Each gene was a mosaic, consisting of DNA pieces that were very similar to the corresponding pieces in the gene from the sensitive strains, along with pieces that differed in about 20 percent of their bases (the chemical units in DNA that determine what amino acids will be inserted in the protein).

The variant pieces must have been acquired from another bacterium. We know that *Neisseria* cells actively take up bits of DNA from their surroundings, preferring DNA similar to their own. The DNA is broken into pieces, and some of the pieces are slotted into the bacterial chromosome, replacing those that are already there. This process of “transformation” is analogous to sex in higher organisms: it is a means whereby genetic material from two ancestors is combined in a single descendant. The difference is that in the sexual process, the new individual gets half its DNA from each parent, whereas in transformation, the recipient cell gets only a small fraction of DNA from a donor. But from an evolutionary point of view, the two processes have similar consequences: favorable mutations occurring in different ancestors can combine in a single descendant.

In the case of *Neisseria*, we know where the introduced blocks of DNA come from. The genus includes not only the bacteria causing meningitis and gonorrhea but also a number of harmless species found in the human throat. Some of these are naturally resistant to penicillin, and were so before the clinical use of antibiotics began. The

introduced blocks are almost identical to the PBP2 genes found in one or the other of two harmless species, *N. flavescens* and *N. mucosa*. Thus *N. meningitidis* evolved resistance to penicillin by acquiring DNA from related species that were already resistant. The same is true of *N. gonorrhoeae*.

The PBP genes in resistant *Streptococcus pneumoniae*, an important cause of respiratory disease, also show a mosaic structure, and we are confident that they too were acquired by genetic transformation. The donor species, however, has not yet been found. (*S. pneumoniae*, incidentally, was the bacterium in which bacterial transformation was first discovered by F. Griffith in 1928. Oswald Avery then demonstrated that the transforming factor was DNA, and this led James Watson and Francis Crick to study the structure of DNA. So began the molecular biology revolution.)

Does transformation play a comparable role in other bacteria now developing resistance to antibiotics? We cannot be sure. Many bacteria, including the geneticist’s favorite, *Escherichia* and *Salmonella*, do not actively obtain outside DNA—they are not, to use the jargon of the microbial genetics, “competent for transformation.” But even these bacteria can acquire DNA from other cells. For example, bacteriophages (viruses that live in bacteria) sometimes carry bacterial DNA into a new host cell by accident.

These and other forms of bacterial evolution, with the consequent spread of antibiotic resistance, are undermining our ability to treat infectious diseases, including the infections that can wreck havoc with any form of surgery. Further cause for concern is the increasing use of bacteria in industrial processes. If genetically engineered organisms are released into the environment, the genes in those organisms are unlikely to remain where we put them. We therefore have to ask not only whether the released organism is harmless but also whether the genes it contains are harmless.

# Extraction of Bacterial DNA

## Introduction

In this activity you will extract a visible mass of DNA from bacterial cells.

The preparation of DNA from any cell type involves the same general steps:

- 1) breaking open the cell (an nuclear membrane, if applicable),
- 2) removing proteins and other cell debris from the nucleic acid, and
- 3) doing a final purification.

These steps can be accomplished in several different ways, and the method chosen generally depends in the purity, needed in the final DNA sample and the relative convenience of the available options.

If a cell is enclosed by a membrane only, the cell contents can be released by dissolving the membrane with detergent. Cell membranes are made of proteins and fats. Just as detergent dissolves fats in a frying pan, little detergent dissolves cell membranes. (The process of breaking open a cell is called cell lysis.) As the cell membranes dissolve, the cell contents flow out, forming a soup of nucleic acid, dissolved membranes, cell proteins, and other cell contents that is referred to as a cell lysate. Additional treatment is required for cells with walls, such as plant cells and many bacterial cells. These treatments can include enzymatic digestion of the cell wall material or physical disruption by means of blending or grinding.

After cell lysis, the next step in a DNA preparation usually involves purification by removing proteins from the nucleic acid. Treatment with protein-digesting enzymes (proteinases) and/or extractions with the organic solvent phenol are two common methods of protein removal. Proteins dissolve in phenol, but DNA does not. Furthermore, phenol and water, like oil and water, do not mix but instead form separate layers. If you add phenol to an aqueous (water-based) DNA-protein mixture like a cell lysate and mix well, the protein dissolves in the phenol. After you stop mixing, the phenol separates from the aqueous portion, carrying the protein with it. The DNA remains in the aqueous layer. To remove the protein simply remove the phenol layer. Following removal of the protein, DNA is usually subjected to additional purification.

In this activity you will not attempt any DNA purification: your goal is simply to see DNA. You will lyse *E. coli* with detergent and layer a small amount of alcohol on top of the cell lysate. Because DNA is insoluble in alcohol, it will form a white, weblike mass (precipitate) at the interface of the alcohol and water layers. By moving a glass rod up and down through the layers, you can collect the precipitated DNA. This DNA is very impure; the mass contains cellular proteins and other debris along with the stringy fibers of DNA.

Before you begin the DNA isolation, make sure you know the procedure to follow. Draw out a flow chart including the volume of cells and the volumes and nature of the reagents you will use.

## Procedure

1. Obtain from your teacher 4 ml of *E. coli* cells and 3 ml of medium in test tubes. Label the tubes. Shake your *E. coli* culture gently to resuspend the cells. Add to each labeled tube 2 ml of a 50 percent solution of dishwashing detergent in water. (Your teacher may substitute some other detergent.) Shake each tube to ensure complete mixing. The detergent contains SDS. SDS is a detergent and an ingredient of many commercial products we buy at the store, such as Woolite and shampoo.
2. Your teacher will provide a 60-70<sup>0</sup>C water bath. Place each tube into the water bath for 15 minutes. *Note:* Maintain the water bath temperature above 60<sup>0</sup>C but below 70<sup>0</sup>C. A temperature higher than 60<sup>0</sup>C is needed to destroy the enzymes that degrade DNA.
3. Cool the tube on ice until it reaches room temperature.
4. For the DNA to be visible, it must be taken out of solution, or precipitated. Watch your teacher demonstrate the following technique. Use a pipette to carefully layer 2 ml of 95 percent ethanol on top of the suspension in each tube. The alcohol should float on top and not mix. (It *will* mix if you stir it or squirt it in too fast, so be careful.) Water-soluble DNA is insoluble in alcohol and precipitates when it comes in contact with it.
5. A weblike mass (precipitate) of DNA will float at the junction of the two layers (the interface). Push a rod through the alcohol into the soup and turn the rod. The rod carries a little alcohol into the soup and makes DNA come out of solution onto the rod. Keep moving the rod through alcohol into the cell soup, and more DNA will appear. *Do not totally mix the two layers.*
6. Observe and draw the tube. Label the different substances in the tube.

## Answer the Questions

1. What was the action of the detergent on the bacteria? Does it behave like this with human cells as well?
2. Why does the alcohol stay on top of the cell suspension and the broth in step 3?
3. What are the proteins associated with DNA and what are their function?

## Content Review Worksheet

**Department:** Life Science

**Date:** 5/11/97

**Target Course:** BIOL 30 Introduction to Biotechnology and Cell Physiology

**Prerequisite:** CHEM 15, 2A or 1A; Principles of Inorganic Chemistry

### LIST OF SKILLS OR KNOWLEDGE NEEDED

1. Knowledge of chemistry and its role fundamental to all other fields of natural science.
2. Knowledge of matter: name and describe the three common forms of matter.
3. Knowledge of differences between pure substance and mixture in terms of composition and properties.
4. Knowledge of the differences between elements and compounds in terms of composition.
5. Knowledge of atomic structure of matter (Atomic Theory).
6. Knowledge of the differences between atoms and molecules.
7. Knowledge of atom structure in terms of nucleus and electrons, positive and negative electric charge and mass distribution.
8. Knowledge of ions: be able to describe ions in terms of gained and lost electrons.
9. Knowledge of the names and symbols of the 13 most common elements found in the human body.
10. Knowledge of electrolytes: their reactivity and importance to the human body.
11. Knowledge of chemical bonding, covalent bonding and ionic bonding in terms of electron sharing, loss or gain.
12. Knowledge of the unique ability of carbon to form a large number of compounds.
13. Knowledge of pH and pH of common body fluids.
14. Knowledge of buffers and introduction to acid-base physiology.
15. Knowledge of using data from graphs, charts, tables and flow diagrams to analyze an outcome.

### Ratings of Relevance

Rating scale: 5=critically relevant; 4=very relevant; 3=moderately relevant; 2= slightly relevant; 1=not relevant.

Skill	Rater #1	Rater #2	Rater #3	Rater #4	Rater #5	Rater #6	Total	Mean
1	5	5	2	2	5	4	23	3.83
2	5	5	3	4	3	5	25	4.17
3	5	3	3	5	3	4	23	3.83
4	5	4	4	5	3	5	26	4.33
5	3	3	4	5	3	5	23	3.83
6	4	3	5	4	3	5	25	4.17
7	5	3	5	4	3	5	25	4.17
8	5	5	5	5	5	5	30	5.00
9	5	5	4	4	5	5	28	4.67
10	5	5	1	5	5	5	26	4.33
11	5	5	2	5	5	5	27	4.50
12	5	5	3	5	4	5	27	4.50
13	5	5	5	5	5	5	30	5.00
14	5	5	5	5	5	5	30	5.00
15	5	5	4	5	4	5	28	4.67

Number of items with a mean rating of 3 or greater is 19. Percentage of items with a mean rating of 3 or greater is 100%.

Department Recommendation:  Prerequisite

**Completed by:** Janet Fulks, Janice Toyoshima, Kenward Vaughan

## Content Review Worksheet

**Department:** Life Science

Date: 5/12/97

**Target Course:** BIOL 30 Introduction to Biotechnology and Cell Physiology

**Prerequisite:** BIOL 10, BIOL 11, BIOL 20 or BIOL 3A—General Biology Course

### LIST OF SKILLS OR KNOWLEDGE NEEDED

1. Knowledge of kingdoms of living organisms.
2. Knowledge of cells and cell membranes.
3. Knowledge of cell types and functions.
4. Knowledge of the four types of biochemicals that compose the organic compounds commonly found in the human body (carbohydrates, fats, proteins, nucleic acids, and the role of each).
5. Knowledge of cell membranes and cell walls and mechanisms of movement across them.
6. Knowledge of pH and its application in living cells.
7. Knowledge of buffers and introduction to acid-base physiology.
8. Knowledge of using data from graphs, charts, tables and flow diagrams to analyze an outcome.
9. Knowledge of anabolism and catabolism reactions in the organisms including dehydration synthesis and hydrolysis.
10. Knowledge of the cellular basis of reproduction and inheritance.
11. Knowledge of patterns of inheritance.
12. Knowledge of the biology of a gene, gene mutation, and factors affecting gene expression.
13. Knowledge of the immune system.

### Ratings of Relevance

Rating scale: 5=critically relevant; 4=very relevant; 3=moderately relevant; 2= slightly relevant; 1=not relevant.

Skill	Rater #1	Rater #2	Rater #3	Rater #4	Total	Mean
1	5	5	2	5	17	4.25
2	5	5	4	5	19	4.75
3	5	5	4	5	19	4.75
4	5	5	5	5	20	5.00
5	4	5	5	5	19	4.75
6	5	5	4	5	19	4.75
7	4	5	4	5	18	4.50
8	5	5	3	5	18	4.50
9	5	5	4	5	19	4.75
10	5	5	2	5	17	4.25
11	5	5	2	5	17	4.25
12	5	5	4	5	19	4.75
13	5	5	3	5	18	4.50

Number of items with a mean rating of 3 or greater is 13. Percentage of items with a mean rating of 3 or greater is 100%.

Department Recommendation:  Prerequisite

**Completed by:** Janet Fulks, Janice Toyoshima, Tom Yale, Wendall Wall

## Equivalent Lower Division Course for Transfer

### *Pepperdine University (1995-96 Academic Catalog)*

#### **Biol 108. Genetics and Human Affairs (4)**

A study of the biological process by which genetic information and common genetic traits are transmitted from one generation to the next. Causes and treatments of common inherited diseases and the biochemical nature of genes are discussed, as well as the current social issues in genetics, including applications of recombinant DNA technology, genetic engineering, genetics or organ and tissue transplantation, and inheritance of intelligence and behavior. Three lectures and one two-hour laboratory per week. Satisfies general education requirement for lab science; does not count for major credit, nor does the grade received count in the major GPA.

### *University of California, Los Angeles*

#### **Biol 9. Introduction to Cell and Molecular Biology** (formerly numbered 7A)

Lecture, three hours; discussion, one hour. Prerequisite: Chemistry 11A. Not open for credit to students with credit for former course 7. Biological macromolecules, energy production, principles of cellular organization and function, and principles of molecular biology.

### *University of California, San Diego*

#### **Biol 1. The Cell (4)**

Introduction to cellular structure and function, to biological molecules, bioenergetics, to the genetics of both prokaryotic and eukaryotic organisms, and to the elements of molecular energy. Three hours of lecture and one hour of recitation. Prerequisites: two quarters of general chemistry (second quarter chemistry may be taken concurrently). (F,W,S)

### *University of California, Davis (1996-97 catalog)*

#### **Biol 10. Introduction to Human Heredity (4) I. Sanders.**

Lecture—3 hours; discussion—1 hour. Topics in human heredity and human gene structure and function, including the genetic basis of human development, causes of birth defects, mental retardation, genetic diseases, sexual determination, development and behavior. Not open to students who have received credit for Genetics 10. (Former course Genetics 10.) GE credit: Sci/Eng Wrt.

### *California State University, Northridge (1994-96 catalog)*

#### **Biol 107. Biological Principles II (3)**

Prerequisite: Chemistry 101. Concurrent enrollment in Biology 107L, and previous or concurrent enrollment in Chemistry 102. An analysis of selected topics illustrating major concepts in biology, including biological chemistry, cells, molecular genetics, animal development, and plant and animal physiology. Lecture 3 hours. Under special circumstances and with approval by the major advisor, students may substitute Biol. 101 for 106 or 107. Students may not receive more than 8 credits for Biol. 101, 106, 106L, 107 & 107L. (Available for General Education, Natural Sciences, if required in the major.)

#### **Biol 107L. Biology Laboratory II (1)**

Observations, experiments and demonstrations intended to augment Biological Principles II. Emphasis on unifying biological concepts and methods in science. Laboratory 3 hours. (To be taken concurrently with Biology 107.) (Available for General Education, Natural Sciences, if required in the major.)

**SCANS COMPETENCIES AND FOUNDATION SKILLS  
ALL ASPECTS OF THE INDUSTRY**

The SCANS five competencies and three-part foundation skills are incorporated into an integrated (vocational and academic), sequenced program that includes school and work-based learning. To what extent are these competencies being met in this course:

**Directions:** Circle the number that best describes the degree to which each component is taught. 1 = 0-25%    2 = 26-50%    3 = 51-75%    4 = 76-100%

**SCANS Competencies**

- Competency 1      Resources: Identifies, Organizes, Plans and Allocates Resources**
- |   |   |   |   |   |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | TIME—selects goal relevant activities, ranks them, allocates time, and prepares and follows schedules         |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | MONEY—uses or prepares budgets, makes forecasts, keeps records, and makes objectives to meet objectives       |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | MATERIAL AND FACILITIES—acquires, stores, allocates and uses materials or space efficiently                   |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | HUMAN RESOURCES—assesses skills and distributes work accordingly, evaluates performance and provides feedback |

- Competency 2      Interpersonal: Works with Others**
- |   |   |   |   |   |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | PARTICIPATES AS A MEMBER OF A TEAM—contributes to group efforts   |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | TEACHES OTHERS NEW SKILLS   |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | SERVES CLIENTS/CUSTOMERS—works to satisfy customers’ expectations.  |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | EXERCISE LEADERSHIP—communicates ideas to justify position, persuades and convinces others, responsibly challenges existing procedures and policies |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | NEGOTIATES—works towards agreements involving exchange of resources, resolves divergent interests   |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | WORKS WITH DIVERSITY—works well with men and women from diverse backgrounds   |

- Competency 3      Information: Acquires And Uses Information**
- |   |   |   |   |   |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | ACQUIRES AND EVALUATES INFORMATION      |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | ORGANIZES AND MAINTAINS INFORMATION     |
| 1 | 2 | 3 | 4 |   |
|   |   |   |   | INTERPRETS AND COMMUNICATES INFORMATION |

<b>Competency 4</b>	<b>Systems: Understands Complex Inter-Relationships</b>
1 2 3 4	UNDERSTANDS SYSTEMS—knows how social, organizational, and technological systems work and operates efficiently with them
1 2 3 4	MONITORS AND CORRECTS PERFORMANCE—distinguishes trends, predicts impacts on system operations, diagnoses deviations in systems performance and corrects malfunctions
1 2 3 4	IMPROVES OR DESIGNS SYSTEMS—suggests modifications to existing systems and develops new or alternative systems to improve performance

<b>Competency 5</b>	<b>Technologies: Works With A Variety of Technologies</b>
1 2 3 4	SELECTS TECHNOLOGY—chooses procedures, tools or equipment including computers and related technology
1 2 3 4	MAINTAINS AND TROUBLESHOOTS EQUIPMENT—prevents, identifies, or solves problems with equipment, including computers and other technologies

### **Foundation Skills**

<b>Skill 1</b>	<b>Basic Skills: Reads, Writes, Performs Arithmetic and Mathematical Operations, Listens and Speaks</b>
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1 2 3 4	READING—locates, understands and interprets written information in prose and in documents such as manuals, graphs and schedules
1 2 3 4	WRITING—communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs and flow charts
1 2 3 4	ARITHMETIC/MATHEMATICS—performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques
1 2 3 4	LISTENING—receives, attends to, interprets, and responds to verbal messages and other cues
1 2 3 4	SPEAKING—organizes ideas and communicates orally

<b>Skill 2</b>	<b>Thinking Skills: Thinks Creatively, Makes Decisions, Solves Problems, Visualizes, Knows How to Learn And Reason</b>
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1 2 3 4	CREATIVE THINKING—generates new ideas
1 2 3 4	DECISION MAKING—specifies goals and constraints, generates alternatives, considers risks, evaluates and chooses best alternative
1 2 3 4	PROBLEM SOLVING—recognizes problems and devises and implements plan of action
1 2 3 4	SEEING THINGS IN THE MIND'S EYE—organizes and processes symbols, pictures, graphs, objects and other information

1	2	3	4	KNOWING HOW TO LEARN—uses efficient learning techniques to acquire and apply new knowledge and skills
1	2	3	4	REASONING—discovers a rule or principle underlying the relationship between two or more objects and applies it in solving a problem
<b>Skill 3</b>				<b>Personal Qualities: Displays Responsibility, Self-Esteem, Sociability, Self Management, and Integrity and Honesty</b>
1	2	3	4	RESPONSIBILITY—exerts a high level of effort and perseveres toward goal attainment
1	2	3	4	SELF ESTEEM—believes in own self-worth and maintains a positive view of self
1	2	3	4	SOCIABILITY—assesses self accurately, sets personal goals, monitors progress and exhibits self control
1	2	3	4	INTEGRITY/HONESTY—chooses ethical courses of action

**Knowledge of “All Aspects of the Industry”**

Means strong experience in, and understanding of, all aspects of the industry the students are preparing to enter.

1	2	3	4	Employers and school personnel jointly design learning outcomes and participate in curriculum development and approval
				The instructional program (vocational and academic, school and work-based) include strong experience in, and knowledge, of the following aspects of the industry on which the instructional program is based:
1	2	3	4	Planning
1	2	3	4	Management
1	2	3	4	Finances
1	2	3	4	Technical and Production Skills
1	2	3	4	Underlying Principles of Technology
1	2	3	4	Health and Safety
1	2	3	4	Staff development efforts enhance necessary skills and appropriate attitudes for faculty, counselors, administrators, workplace instructors and supervisors
1	2	3	4	Work-based activity explicitly reinforces academic and technical lessons
1	2	3	4	Students are engaged in real, productive work
1	2	3	4	Other _____
1	2	3	4	Other _____
1	2	3	4	Other _____