I. Biology Program

1) The Biology Major encompasses an overall knowledge of biological concepts with an emphasis on preparation for a broad biological knowledge base. Students will graduate with knowledge of biology, ecology, and chemistry, combined with critical thinking and writing skills, to assist them in any further education or field of work they might choose.

2) The Missouri Valley College mission statement is: Guiding students to succeed through personal instruction and intellectual inquiry. The Biology Major is congruent with this mission in that, from freshman biology (BI-104) to junior/senior level courses (such as microbiology, genetics, ecology, wildlife ecology and management, etc), the biology faculty increasingly get to know the students and can personally guide them on their intellectual quest for knowledge and skills that will help our biology graduates succeed in any area of biology.

3) The Biology major is for those interested in going on to graduate or professional schools or finding work in conservation or wildlife management. This major ensures that students:
- Acquire a broad foundation across all levels and disciplines in biology
- Develop analytical and critical thinking skills
- Develop scientific writing and communication skills
- Understand the scientific method and process
- Understand natural selection and evolution
- Understand prokaryotic and eukaryotic cell biology
- Understand ecological concepts and quantitative analysis of data
- Understand concepts Mendelian and molecular genetics
- Understand animal and plant phylogeny and morphology
- Understand concepts in the chemical foundations of biology
- Explore general concepts in biology, chemistry, and physics in depth
- Understand the structure, properties, composition, reactions, and preparation of carbon-based compounds
- Understand the chemical processes in living organisms

4) Biology contributions to General Education:
- BI104 Principles of Biology (Core II 2011-2012; Core III A. 2012-2013)
- BI124 Human Biology (Core II 2011-2012)
- BI130 Plants and People (Core II 2011-2012; Core III A. 2012-2013)
5) **Biology Curriculum**

BI 104. Principles of Biology - 4 hours.
Concepts and principles common to the living world; protoplasmic and cellular nature of living things; metabolism, its biochemical and biophysical foundation; heredity; evolution; ecological relationships. Three lectures, one lab per week. $25.00 lab fee. Fall. Spring.

BI 130. Plants and People - 3 hours.
Overview of plant cellular and macroscopic structure, function, evolution and diversity leading into technological applications of plants. Technologies used in agricultural production of food, fiber, fuel and medicine will be covered. Ecological and social issues raised by agricultural technologies will also be discussed. Fall.

BI 210. General Botany - 4 hours.
General structure, physiology, reproduction, heredity and ecology of plants, brief survey of plant world. Three lectures, two laboratories per week. Prerequisite: BI 104 or permission of instructor. $25 lab fee. Spring.

BI 212. Vertebrate Zoology – 4 hours.
A study of the general biology and natural history of the vertebrata, including the morphology, physiology, ecology and evolution of vertebrates with emphasis on North American species. The laboratory section of this course focuses on comparative anatomy of the vertebrates. Three lectures, two laboratories per week. Prerequisite: BI 104. $50 lab fee. Fall odd years.

BI 215. General Zoology – 4 hours.
A study of the form and function, characteristics, and evolutionary development of the different phyla in the Kingdom Animalia. Three lectures, two laboratories per week. Prerequisite: BI 104. $50 lab fee. Fall even years.

BI 250. Introduction to Cell Biology - 3 hours.
Study of the structure and function of eukaryotic cells, including membrane systems, organelles and reproduction. Prerequisite: BI 104. Spring.

BI 255. Principles of Human Anatomy and Physiology . 4 hours.
This course deals with foundation and concepts of Human Anatomy and Physiology, beginning with the cellular and histologic levels and quickly advancing to the systems of the body. Three lectures, two laboratories per week. Prerequisite: “C” or better in BI 104. CH 111 is recommended, but not required. $50 lab fee. Fall.

BI 275. Human Anatomy and Physiology I – 4 hours.
Foundations and concepts of Human Anatomy and Physiology, starting at the cellular level and advancing into the nervous, skeletal, muscular, respiratory, and cardiovascular systems. Three lectures, two laboratories per week. Prerequisite: C or better in BI 104. CH 111 is recommended, but not required. $50 lab fee. Fall. Spring.
BI 285. Human Anatomy & Physiology II – 4 hours.
Advanced concepts in Human Anatomy and Physiology, including the nervous, endocrine, lymphatic, digestive, urinary, integumentary, immune, and reproductive systems. Three lectures, two laboratories per week. Prerequisite: C or better in BI 104, BI 275. CH 111 is recommended but not required. $50 lab fee. Fall.

BI 300. Ichthyology – 4 hours.
Natural history of the fishes, including taxonomy, biology, ecology, and evolution with an emphasis on local species. Three lectures and one 3-hour lab per week. $50 lab fee. Prerequisites: BI 104 and BI 212 or BI 215. Fall even years.

BI 305. Ornithology – 4 hours.
Biology of birds with an emphasis on field identification of local avian species as well as anatomy, physiology, ecology, evolution, and behavior of birds in general. Three lectures and one 3-hour lab per week. $50 lab fee. Prerequisites: BI 104 and BI 212 or BI 215. Spring even years.

BI 306. Herpetology – 4 hours.
Natural history of the amphibians and reptiles, including ecology, biology, evolution, and anatomy with an emphasis on local species. Three lectures and one 3-hour lab per week. $50 lab fee. Prerequisites: BI 104 and BI 212 or BI 215. Spring odd years.

BI 310. Mammalogy – 4 hours.
(Lab BI 309) In lecture, students will be introduced to the diversity of mammals and be exposed to the taxonomy, form and function, distribution, natural history ecology, conservation and economic importance of mammals with emphasis put on Missouri and regional species. In Laboratory, students will be introduced to approximately 72 representative species of mammals that are located in Missouri and the region and will be expected to master the techniques and processes used in taxonomy and systematic for identifying mammals from laboratory and field collections. $50 lab fee. Prerequisites: BI 104 and BI 212 or BI 215. Spring even years.

BI 316. History of Science - 3 hours.
Biographical approach to scientific thought from ancient through modern civilization. Prerequisite: Permission of instructor. Fall odd years. BI 320. Principles of Microbiology - 4 hours.

BI 320. Principles of Microbiology – 4 hours.
Biology of microorganisms; the handling, culture and identification of bacteria. Three lectures, two laboratories per week. $50 lab fee. Prerequisite: BI 104. BI 250 and CH 111 are recommended, but not required. Fall.

BI 323. Genetics - 4 hours.
Principles of genetics, examined at the molecular, cellular, organism and population levels of organization. Laboratory work demonstrates Mendelian inheritance and the cytological basis of genetics. Three lectures, two labs per week. $30 lab fee. Prerequisite: BI 104, MA 200. Spring.
BI 332. Ecology - 4 hours. Relationships of living organisms to their environment; analysis of structure and succession of natural communities; analysis of population control mechanisms; current problems in ecology. Three lectures, one three hour lab per week. $50 lab fee. Prerequisite: BI 104, MA 200, junior/senior standing, or permission from instructor. Spring

BI 335. Dendrology – 2 hour. Identification of trees, shrubs, and woody vines. Emphasis will be on Missouri native species, but will also include a few important ornamental species. Basic ecology of trees including preferred habitats of major species, economic uses and function in forest systems. This course is designed for those interested in conservation biology and wildlife ecology, but open to anyone with an interest in plants and trees. Field trips are required. $20 lab fee. Prerequisite: BI 210 or permission of instructor.

BI 149/249/349/449. Special Topics in Biology 1-6 hours. Advanced students wishing to undertake special projects or research problems can do so in this course. Prerequisite: varies by topic.

BI 350. Pathophysiology – 3 hours. This course provides an in-depth study of human pathological processes and their effects on homeostasis. Emphasis is on interrelationships among organ systems in deviations from homeostasis. Upon completion, students should be able to demonstrate a detailed knowledge of pathophysiology. Course topics include the etiology, physical signs and symptoms, prognosis, and complications of commonly occurring diseases and their management. Prerequisites: BI 104, BI 255 or BI 275. Spring.

BI 401. Internship in Biology - 1-9 hours. Internship under supervision of college personnel and cooperating facility. Prerequisite: Biology major and permission of division dean and Chief Academic Officer. Arranged.

BI 403. Entomology - 4 hours. A study of the structure, function, evolution and impact of the insect group; experience on collection, curation, and identification of the major orders and families. $30 lab fee. Prerequisite: BI 104. Fall odd years.

BI 404. Wildlife Ecology and Management – 3 hours. The application of ecological principles to the management of vertebrate populations and their habitats to meet the needs of those populations and the needs of people. Prerequisites: BI 332, junior/senior standing, or permission of instructor. Spring odd years.

BI 413. Field Biology – 3 hours. Through intensive field investigation, along with readings on the biology of a specific ecological area and arranged seminars, the student will be exposed to an ecosystem typically outside of Missouri (e.g., the Chihuahuan Desert). An extended field trip to the area of interest is required. Lab Fee: $200-$500 Dependent on Destination. Prerequisites: Junior/Senior standing, BI 332 (may be taken concurrently). Course may be repeated for credit for a maximum of 6 hours. Spring.
BI 420. Conservation Biology Seminar – 2 hours. Conservation Biology is a highly interdisciplinary field that studies biodiversity, the natural processes that control it and the maintenance of biodiversity under the increasing pressures of humans. This course will utilize lecture, articles from the primary literature and presentations from researchers in the field of conservation biology. This course is a capstone course for the Conservation Concentration within the biology major. Students will be required to write an extensive literature review and give a presentation. Prerequisite: BI 332, Junior or Senior standing. $20 fee. Spring even years.

BI 425. Evolution Seminar - 2 hours. Discussion of recent papers in population genetics and evolutionary processes. Topics include the genetic structure of populations, genetic drift, natural selection, co-evolution, speciation, and the fossil record. Two meetings per week. Prerequisite: BI 323. Fall even years.

BI 430. Taxonomy of Higher Plants - 4 hours. Classification and identification of flowering plants; local flora and field techniques. Three lectures, two laboratories per week. $50.00 lab fee. Prerequisite: BI 210 or permission of instructor. Fall even years.

BI 376/476. Independent Study - 1-3 hours. Reading or research at a greater depth than in a normal class. Prerequisite: Permission of the instructor, division dean and Chief Academic Officers

6) Degree requirements
BI104, BI 210, BI 212 or 215, BI 250, BI 320, BI 323, BI 332, CH 111, CH 112, MA 200, AY 315, CH 331, BI 316, BI 425, 1 course from: CH 332, CH300 or CH 451. 1 course from BI 413, BI 415 or BI 376/476. 1 course from BI 350 or BI 430. 3 courses from BI 255 or BI 275, BI 300, BI 306, BI 305, BI 376 or BI 476, BI 403, BI 310.

7) Other Information
The biology degree program at MVC has a strong history of undergraduate research. Students have the opportunity to design their own research project as part of an independent study project and or participate in ongoing research being conducted by faculty, the Missouri Department of Conservation, or local non-profit organizations such as the Missouri River Bird Observatory.
8) Status of the discipline, including emerging issues and trends
Biology is an important field in modern society. It is the basis for applied fields such as medicine, wildlife/resource management and biotechnology. The products of biological research are increasingly becoming important to society as a whole. With the human population still growing, conservation biology and agricultural production are growing areas of concern. The newest area of emphasis in the last twenty years or so has been in that of molecular biology, which is the use of DNA and protein data for the study of living organisms. This new avenue of research has impacted nearly every other field in biology and will continue to bring new therapies, methodologies and products to the world as a whole.

Outlook of potential career options for biology majors (careers requiring a Master’s degree or PhD for entry level positions were not included in the following summary).

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Entry Level Education</th>
<th>Work Experience in a related Occupation</th>
<th>Projected Number of New Jobs 2010-2020</th>
<th>Projected Growth Rate 2010-2020</th>
<th>2010 Median Pay</th>
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<tbody>
<tr>
<td>Agricultural and Food Scientists</td>
<td>Bachelor’s Degree</td>
<td>None</td>
<td>1,000 – 4,900</td>
<td>10 – 19%</td>
<td>$55,000 - $74,999</td>
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<td>Biological Technicians</td>
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<td>10 – 19%</td>
<td>$35,000 - $54,999</td>
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<td>Conservation Scientists</td>
<td>Bachelor’s Degree</td>
<td>None</td>
<td>1,000 – 4,900</td>
<td>0 – 9%</td>
<td>$55,000 - $74,999</td>
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<td>Dietitians and Nutritionists</td>
<td>Bachelor’s Degree</td>
<td>Internship / Residency</td>
<td>10,000 – 49,000</td>
<td>20 – 28%</td>
<td>$35,000 - $54,999</td>
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<td>Environmental Engineers</td>
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<td>None</td>
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<td>20 – 28%</td>
<td>$75,000 or more</td>
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<td>Environmental Scientists and Specialists</td>
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<td>$55,000 - $74,999</td>
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<td>Foresters</td>
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<td>0 – 9%</td>
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<td>Forensic Scientist Technicians</td>
<td>Bachelor’s Degree</td>
<td>Moderate-term on-the-job training</td>
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<td>Medical Laboratory Technologists</td>
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<td>Zoologists and Wildlife Biologists</td>
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<td>0 – 9%</td>
<td>$55,000 - $74,999</td>
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See Appendix A for Biology Job Descriptions, Outlooks, Requirements, and Salaries.
II. Faculty/Student Information

1) Current full-time faculty (see attached vitae.)

FULL-TIME

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<tr>
<th>Name</th>
<th>Division</th>
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<tbody>
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<td>Katherine Adams</td>
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<tr>
<td>John Gault</td>
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<td>Waylon Hiler</td>
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<td>Jeffery Kimmons</td>
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<td>Sarah MacDonald</td>
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<td>Marilyn Milovich</td>
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<td>Erich Mueller</td>
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<td>Stephen Patton</td>
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<td>Michele Reinke</td>
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<td>William Romine</td>
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<tr>
<td>Allan Wilson</td>
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</table>

2) Current adjunct faculty: Number of adjunct: ______1___________

3) Faculty professional development activities
   Biology faculty use the following for professional development
   • membership in various scientific societies including membership to society journals containing primary literature
   • presentation of research at profession conferences
   • publication of research in scientific journals
   • attending professional conferences and workshops

4) Student information this past year

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<tr>
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<th>Fall</th>
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<th>Spring</th>
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<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
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<tr>
<td>Majors</td>
<td>38</td>
<td>33</td>
<td>71</td>
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<td>Minors</td>
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<tr>
<td>Graduating seniors</td>
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5) **Number of graduates over last five years**

<table>
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<th>Fall</th>
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<th>Spring</th>
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<td>Male</td>
<td>Female</td>
<td>Total</td>
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<td>2008-2009</td>
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<td>2011-2012</td>
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6) The students we have maintained contact with have had great success obtaining employment in the work force or acceptance into graduate programs. Of the 52 biology graduates over the past 5 years, we have been able to get job information on 35. The break down of job placement is as follows:

- **11 (31%) are employed in an unrelated field.** Three of these graduates previously held positions in biology but moved on to other opportunities. A few others are in the process of applying to graduate, vet, or medical school. One of the challenges a few of these graduates has had in obtaining a biology job is the inability and/or unwillingness to relocate.

- **7 (20%) are employed in a medical related field (vet, vet assistant, dental hygienist)**

- **6 (17%) are attending graduate school**

- **6 (17%) are employed as teachers**

- **4 (12%) are working as lab technicians/field biologists**

- **1 (3%) is working in sales of biological equipment**

In summary, 69% of the graduates we are in contact with have a job or are attending school in a biology related field.
III. Program Assessment and Planning

1) Student learning outcomes of the program

1. Develop an appreciation for living organisms and biological processes
2. Engage in current thinking, discoveries and methodologies in biology
3. Develop analytical and critical thinking skills
4. Develop scientific writing and communication skills
5. Understand the scientific method and process
6. Understand natural selection and evolution
7. Understand prokaryotic and eukaryotic cell biology
8. Understand ecological concepts and quantitative analysis of data
9. Understand the concepts of Mendelian and molecular genetics
10. Understand animal and plant phylogeny and morphology
11. Understand concepts in the chemical foundations of biology
12. Explore general concepts in biology, chemistry, and physics in depth

IV. Course map

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</tr>
<tr>
<td>BI305</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BI403</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BI310</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
2) Means of assessing student learning outcomes

Assessment tools - The ACAT biology test addresses the following learning outcomes in the following sections:

- Evolution: SLO6
- Cellular Biology: SLO7
- Genetics: SLO9
- Vascular Botany: SLO10
- Ecology: SLO8

3) Describe level of achievement of student learning outcomes

ACAT scores range from 200 to 800 with an average of 500 and a standard deviation of 100. ACAT scores are based on a reference group of 2937 graduating students taking an ACAT exam in Biology. Graduating Missouri Valley College Biology students have an overall 409, which is within a standard deviation of ACAT’s average (500).

Scoring for individual areas of Biology indicate Missouri Valley Biology students scored the highest in Ecology and lowest in Cellular Biology. In order to fall within two standard deviations of the national average (500), students need an approximate score of 400 to 600. Missouri Valley Biology students met this goal for all areas of Biology except Cellular Biology.

<table>
<thead>
<tr>
<th>Area</th>
<th>Standard Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Biology</td>
<td>380</td>
</tr>
<tr>
<td>Ecology</td>
<td>470</td>
</tr>
<tr>
<td>Genetics</td>
<td>433</td>
</tr>
<tr>
<td>Vascular Biology</td>
<td>443</td>
</tr>
<tr>
<td>Evolution</td>
<td>436</td>
</tr>
<tr>
<td>Overall Performance</td>
<td>409</td>
</tr>
</tbody>
</table>

The overall performance of our Biology Majors is on the lower end of the standard deviation range for the national average (400 to 600). The lowest score is for cellular biology and the highest score is for ecology; this is probably a reflection of two factors, 1) most students take cellular biology in their sophomore/junior years while they usually take ecology in their last semester before graduation, a time much closer to the ACAT test; and closely related to that is 2) cellular biology has about 25 to 30 students per class whereas ecology has about 10 to 15 students [this is a problem of student retention]. Students reaching ecology class (i.e. soon to be graduating seniors) are more knowledgeable about biology and are more dedicated to succeed in biology.
4) **Evaluate effectiveness of assessment methods used**

The main problem with the ACAT as it is currently used is that it is not tied into a grade or student performance in a class or for graduation. It is given as a stand-alone test and, however well or bad a student does on the ACAT, the ACAT’s assessment will not affect the student’s GPA or grade in any class. The students know this, and all too many of them simply try to get through the exam as fast as possible.

The biology faculty are aware of this and we are trying to correct it by some combination of: using a different assessment tool (possibly the GREs biology exam); having the assessment tool be a part of the grade for one (or more) of the upper level courses; include it along with student portfolios; the creation of a capstone course, internship results, and/or independent study; and finally make passing the assessment exam be contingent to graduating. Making these changes will allow for assessment of all student learning outcomes and a more accurate assessment of the major.

5) **Summarize improvements made based on the results of the assessment**

The biology faculty are currently trying to revise the assessment tool (ACAT) and therefore cannot summarize improvements based on it.

6) **Brief analysis of grade patterns of courses with high failure rates and/or withdrawals and action plan for student improvement in these courses**

BI-104 Principles of Biology, the entry level course for the biology major and the Core III, Section A, General Education Core Curriculum class is the course with the highest failure/withdrawal rate. This course includes both biology majors and non-majors and has always a large enrollment.

For the Fall 2012/Spring 2013 year: Total: 222 students

- Pass: 172
- Fail: 50
- Withdrawal: 5

This gives a failure/withdrawal rate of 25%

Years ago this course was split into a two track system: one for majors and another for non-majors but that did not work out (the non-majors were not learning very much biology or science and that was not good for a liberal arts education), and the two tracks were recombined into the current BI-104 course.

The current action plan for improving the failure/withdrawal rate for this course is have the biology majors take it their first (freshman) year and the non-majors to take it in their sophomore or later years when they are more ready for intellectual challenges.
IV. Facilities and Resources

Classrooms
The classrooms used for biology courses are adequate and are most are equipped with technology to enhance learning.

Lab Facilities
The college has been addressing the aging equipment and facilities over the past few years. Four of the labs have been completely renovated and equipped with new equipment. The two chemistry labs have been outfitted with new hoods, but are still in need of further renovations. If the number of biology majors and students from other majors taking biology courses continues to increase, it will become challenging to accommodate all of the course time slots.

Equipment/Technology
In recent years, the college has been replacing some equipment a little at a time, but there is still a need to replace several aging items. This is especially true in the health related courses due to an increase in enrollment. If the anticipated increase in conservation students occurs over the next few years, there will be an even greater need to purchase more field equipment.

Personnel
Due to an increase in the college and biology major enrollment, the number of full time faculty teaching science courses has increased from 5 to 8. Even with the increase, faculty are stretched thin at times to meet the needs of the general education, nursing, health science, dance, honors, and biology courses. The recent addition of another chemistry/physical scientist position has alleviated some of this pressure.

Library
Our library resources and online subscriptions are adequate.

Other Resources
Missouri Valley College is a member of the Reis Biological Station Consortium. This is an excellent asset that is used to enhance learning in many biology courses.

Missouri Valley College is also a recent member of the Missouri Academy of Science. This resource will allow our students access to research and presentation opportunities.

Little funding or faculty incentive is available for undergraduate research.
V. Strengths, Weaknesses, Opportunities, and Threats (SWOT)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Offering specialty courses not available at similar sized institutions</td>
<td>• Heavy teaching load</td>
</tr>
<tr>
<td>• Hands on experience including multiple field courses utilizing off-campus facilities</td>
<td>• Staff with non-terminal degrees</td>
</tr>
<tr>
<td></td>
<td>• Limited budget for research and equipment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Strong relationships with local government and private agencies for volunteering and internships</td>
<td>• Lacking a chemistry major for premedical students</td>
</tr>
<tr>
<td></td>
<td>• Lacking compensation for faculty time and funds to establish a research program</td>
</tr>
</tbody>
</table>

VI. Conclusion and Vision

1) Status of program: growing
The biology program is growing slightly (with some year to year variation). We are currently graduating around ten students per year.

2) Major strengths/accomplishments of the program over the last five years
There has been a major expansion in the biology program over the last five years mainly due to the addition of the new nursing program. Students enrolling in nursing are required to take BI 104 (Principles of Biology), BI-275/BI-285 (Anatomy and Physiology), and BI-320 (Microbiology). This has necessitated the hiring of a full A&P faculty and the doubling of microbiology labs due to increased enrollment in these courses.

3) Vision statement of what the program members would like the program to be in five years (improvement goals)
The biology faculty are personally and professionally engaged in preparing thoughtful citizens for meaningful lives and careers in biology. Successful graduates will understand fundamental biological principles in depth, will have laboratory and field skills to answer biological questions, will have enhanced critical thinking and quantitative skills, and will be able to communicate precisely and analytically in written and oral forms so as to be thoughtful and productive contributors to society. To accomplish this goal we have developed three concentrations in biology to provide our students with the background necessary to pursue graduate education (MS, PhD in biology), professional studies (such as medical school or veterinary school, etc), or employment in conservation and wildlife management fields. With such knowledge, our graduating biology majors will be able to succeed in a knowledge-based global society.
4) Strategies and resources required for achieving the program vision

One weakness of the biology program is the loss of students from freshmen to graduating seniors (going from about 70 freshmen majors to about 10 graduating seniors). This is both a College and a program level problem as well as a problem in science and math field in general. Approximately 40% of students in engineering and science nationwide switch to other majors or fail to graduate. When PreMed students are included this goes to 60% [1].

Missouri Valley College is attempting to address this issue (e.g. improve dorms, food service, etc). The biology program is also trying to address this issue for the biology majors, particularly the freshmen/sophomore students. The initial courses in the biology major (BI-104 Principles of Biology; BI-210 Botany; BI-250 Cellular Biology) are designed to provide a basic information background to the student before they advance to higher level courses. These are memorization intensive courses where the students learn the basic informational tools needed for more advanced courses; this is much like learning a language: one needs to learn the words and meanings of words before one can begin speaking or reading a language.

[1] (Why Science Majors Change Their Minds (It’s Just So Darn Hard) NY Times- Nov 4, 2011)

VII. List of individuals who assisted in the completion of this report
Jeff Kimmons
Waylon Hiler
Michele Reinke
Alan Wilson
Sarah J MacDonald
Appendix A: Biology Job Descriptions, Outlooks, Requirements, and Salaries.

Agricultural and Food Scientists

What Agricultural and Food Scientists Do
Under the supervision of scientists, agricultural and food science technicians measure and analyze the quality of food and agricultural products.

Duties:
- Conduct research and experiments concerning animal nutrition and field crops
- Develop ways to improve the quantity and quality of field crops and farm animals
- Create new food products and develop new and better ways to process, package, and deliver them
- Study the composition of soil as it relates to plant growth
- Communicate research findings to the scientific community, food producers, and the public

Agricultural and food scientists play an important role in maintaining the nation’s food supply. Many work in basic or applied research and development. Basic research seeks to understand the biological and chemical processes by which crops and livestock grow. Applied research uses this knowledge to discover ways to improve the quality, quantity, and safety of agricultural products. Many agricultural and food scientists work with little supervision, forming their own hypotheses and developing research methods accordingly. In addition, they often lead teams of technicians or students who help in their research.

The following are types of agricultural and food scientists:
- **Animal scientists** typically conduct research on domestic farm animals. With a focus on food production, they explore animal genetics, nutrition, reproduction, diseases, growth, and development. They work to develop efficient ways to produce and process meat, poultry, eggs, and milk. Animal scientists may crossbreed animals to get new combinations of desirable characteristics. They advise farmers on how to upgrade housing for animals, lower animal death rates, handle waste matter, and increase production.
- **Food scientists and technologists** use chemistry and other sciences to study the underlying principles of food. They analyze nutritional content, discover new food sources, and research ways to make processed foods safe and healthy. Food technologists generally work in product development, applying findings from food science research to develop new or better ways of selecting, preserving, processing, packaging, and distributing food. Some food scientists use nanotechnology to develop sensors that can detect contaminants in food. Other food scientists enforce government regulations, inspecting food processing areas to ensure that they are sanitary and meet waste management standards.
- **Soil and plant scientists** conduct research on soil, crops, and other agricultural products. Soil scientists examine the scientific composition of soil as it relates to plant or crop growth, and investigate effects of alternative soil treatment practices on crop productivity. They develop methods of conserving and managing soil that farmers and forestry companies can use. Because soil science is closely related to environmental
Science, people trained in soil science also work to ensure environmental quality and effective land use.

Plant scientists work to improve crop yields and give advice to food and crop developers about techniques that could enhance production efforts. They develop ways to control pests and weeds safely and effectively.

Agricultural and food scientists in private industry commonly work for food production companies, farms, and processing plants. They typically improve inspection standards or overall food quality. They spend their time in a laboratory, where they do tests and experiments, or in the field, where they take samples or assess overall conditions. Other agricultural and food scientists work for pharmaceutical companies, where they use biotechnology processes to develop drugs or other medical products. Some look for ways to use agricultural products for fuels, such as ethanol produced from corn.

At universities, agricultural and food scientists do research and investigate new methods of improving animal or soil health, nutrition, and other facets of food quality. They also write grants to organizations such as the United States Department of Agriculture (USDA) or the National Institutes of Health (NIH) to get steady funding for their research. In the federal government, agricultural and food scientists conduct research on animal safety and methods of improving food and crop production. They spend most of their time conducting clinical trials or developing experiments on animal and plant subjects. Agricultural and food scientists eventually present their findings in peer-reviewed journals or other publications.

How to Become an Agricultural or Food Scientist

Agricultural and food scientists need at least a bachelor’s degree from an accredited postsecondary institution, although many obtain a doctoral degree. Food scientists and technologists and soil and plant scientists typically earn bachelor’s degrees. Some scientists earn a Doctorate of Veterinary Medicine (DVM). Most animal scientists earn a Ph.D.

Every state has a land-grant college that offers agricultural science degrees. Many other colleges and universities also offer agricultural science degrees or agricultural science courses. Degrees in related sciences, such as biology, chemistry, or physics, or in a related engineering specialty also may qualify people for many agricultural science jobs.

Undergraduate coursework for food scientists and technologists and for soil and plant scientists typically includes biology, chemistry, botany, and plant conservation. Students preparing to be food scientists take courses such as food chemistry, food analysis, food microbiology, food engineering, and food processing operations. Students preparing to be soil and plant scientists take courses in plant pathology, soil chemistry, entomology (the study of insects), plant physiology, and biochemistry.

Students typically gain a strong foundation in their field, with an emphasis on teamwork, internships, and research opportunities. In addition to science coursework, undergraduates sometimes take humanities courses, which help them develop good communication skills. Many people with bachelor’s degrees in agricultural sciences find work in related jobs rather than becoming an agricultural or food scientist. For example, a bachelor’s degree in agricultural science is useful for managerial jobs in farm-related or ranch-related businesses, such as farming, ranching, agricultural inspection, farm credit institutions, or companies that make or sell feed, fertilizer, seed, and farm equipment.
Graduate study further develops an animal scientist’s knowledge, and it typically takes students 6 years to complete their Ph.D. During graduate school, there is additional emphasis on lab work and original research, where prospective animal scientists have the opportunity to do experiments and sometimes supervise undergraduates. Advanced research topics include genetics, animal reproduction, and biotechnology, among others. Advanced coursework also emphasizes statistical analysis and experiment design, which are important as Ph.D. candidates begin their research. Some agricultural and food scientists receive a Doctor of Veterinary Medicine before they begin their animal science training. Like candidates for a Ph.D. in animal science, a prospective veterinarian must first have a bachelor’s degree before getting into veterinary school.

Important Qualities:

- **Communication skills.** Communication skills are critical for agricultural and food scientists. They must be able to explain their studies: what they were trying to learn, the methods they used, what they found, and what they think the implications are of their findings. They must also be able to communicate well when working with others, including technicians and student assistants.

- **Critical-thinking skills.** Agricultural and food scientists must use their expertise to determine the best way to answer a specific research question.

- **Data-analysis skills.** Agricultural and food scientists, like other researchers, collect data using a variety of methods, including quantitative surveys. They must then apply standard data analysis techniques to understand the data and get the answers to the questions they are studying.

- **Decision-making skills.** Agricultural and food scientists must use their expertise and experience to determine whether their findings will have an impact on the food supply, farms, and other agricultural products.

- **Observation skills.** Agricultural and food scientists conduct experiments that require precise observation of samples and other data. Any mistake could lead to inconclusive or inaccurate results.

Agricultural and food scientists can get certifications from organizations like the American Registry of Professional Animal Scientists (ARPAS), or the Soil Science Society of America (SSSA). These certifications recognize expertise in agricultural and food science and enhance the status of those who are certified. According to the organizations, certification of professional expertise is broadly based on education, a comprehensive exam, and previous professional experience. Scientists must take continuing education courses every year to keep their certification, and they must follow the organization's code of ethics. Certification is not required, but the agricultural and food science community recognizes its importance. Some states require soil scientists to be licensed to practice. Licensing requirements vary by state, but generally include holding a bachelor’s degree with a certain number of credit hours in soil science, a certain number of years working under a licensed scientist, and passage of an examination.

**Pay**
The median annual wage of agricultural and food scientists was $58,450 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that
amount and half earned less. The lowest 10 percent earned less than $34,320, and the top 10 percent earned more than $105,040.

Median annual wages in selected industries for animal scientists in May 2010 were the following:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$86,550</td>
</tr>
<tr>
<td>Professional, scientific, and technical services</td>
<td>$76,790</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state, local, and private</td>
<td>$49,250</td>
</tr>
</tbody>
</table>

Median annual wages in selected industries for food scientists and technologists in May 2010 were the following:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research and development services</td>
<td>$69,470</td>
</tr>
<tr>
<td>Food manufacturing</td>
<td>$55,690</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state, local, and private</td>
<td>$46,940</td>
</tr>
</tbody>
</table>

Median annual wages in selected industries for soil and plant scientists in May 2010 were the following:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research and development services</td>
<td>$62,210</td>
</tr>
<tr>
<td>Professional, scientific, and technical services</td>
<td>$57,680</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state, local, and private</td>
<td>$46,630</td>
</tr>
</tbody>
</table>

Job Outlook
Employment of agricultural and food scientists is expected to increase by 10 percent from 2010 to 2020, about as fast as the average for all occupations. Ongoing animal science research, as well as an increased reliance on food safety through biotechnology and nanotechnology, is expected to increase demand for agricultural and food scientists moderately. Agricultural scientists will also be needed to balance increased agricultural output with protecting and preserving soil, water, and ecosystems. They increasingly will help develop sustainable agricultural practices by creating and carrying out plans to manage pests, crops, soil fertility, erosion, and animal waste in ways that reduce the use of harmful chemicals and minimize damage to the natural environment. In addition, demand for biofuels—renewable energy sources from plants—is expected to increase.

Job growth for food scientists and technologists is expected to be driven by the demand for new food products and food safety measures. Food research is expected to increase because the public is more aware of nutrition, health, food safety, and the need to keep herd animals from getting infections.
Most growth over the next 10 years for agricultural and food scientists will be in private industry. Private industry has increased its demand for agricultural and food scientists because their expertise is necessary for developing food, crops, and drugs, along with ensuring quality and safety.

Furthermore, research in genomics and agricultural sustainability also is expected to increase the number of available agricultural science positions. Findings from these scientists' studies may improve crop yields or have an impact on other fields, such as biofuels.


Biological Technicians

What Biological Technicians Do

Biological technicians help biological and medical scientists conduct laboratory tests and experiments.

Duties:

- Biological technicians typically do the following:
- Set up, maintain, and clean laboratory instruments and equipment, such as microscopes, scales, and test tubes
- Gather and prepare samples of substances, such as blood, food, or bacteria cultures, for laboratory analysis
- Conduct biological tests and experiments
- Document their work, including procedures, observations, and results
- Analyze experimental data and interpret results
- Write reports that summarize their findings

Most biological technicians work on teams. Typically, technicians are responsible for doing scientific tests, experiments, and analyses under the supervision of biologists or other scientists who direct and evaluate their work. Biological technicians use traditional laboratory instruments and advanced robotics and automated equipment to conduct experiments. They use specialized computer software to collect, analyze, and model experimental data. Biological technicians work in many areas of research. They may assist with medical research by helping develop new medicines and treatments used to prevent, treat, or cure diseases. Biological technicians who work in microbiology, sometimes referred to as laboratory assistants, studying living organisms and infectious agents. Technicians working in biotechnology apply the knowledge and techniques they have gained from basic research to product development.

How to Become a Biological Technician

Biological technicians typically need a bachelor’s degree in biology or a closely related field. It is important for prospective biological technicians to gain laboratory experience while they are in school. Biological science programs usually include courses in general biology, as well as in specific subfields such as ecology, microbiology, and molecular biology. In addition to taking
courses in biology, students must study chemistry, mathematics, and physics. Computer science courses are helpful for modeling and simulating biological processes and for operating some laboratory equipment. It is important for students to gain laboratory experience before entering the workforce. Students should take biology courses that emphasize laboratory work. They often can also gain laboratory experience through summer internships with prospective employers, such as pharmaceutical and medicine manufacturers.

Important Qualities:

- **Analytical skills.** Biological technicians need to be able to conduct scientific experiments and analyses with accuracy and precision.
- **Critical-thinking skills.** Biological technicians draw conclusions from experimental results through sound reasoning and judgment.
- **Listening skills.** Biological technicians must carefully follow the instructions of biochemists, microbiologists, and other scientists when carrying out experiments and analyses.
- **Observation skills.** Biological technicians must constantly monitor their experiments. They need to keep a complete, accurate record of their work, such as the conditions under which the experiment was carried out, the procedures they followed, and the results they obtained.
- **Teamwork.** Biological technicians work together on teams under the direction of biologists or other scientists.
- **Technical skills.** Biological technicians must be able to set up and operate sophisticated equipment and instruments. They also may need to adjust equipment to ensure that experiments are conducted properly.
- **Writing skills.** Biological technicians must write reports that summarize their findings and results clearly.

Biological technicians may be able to advance to scientist positions, such as microbiologist, after a few years of experience working as a technician or after earning a graduate degree.

**Pay**
The median annual wage of biological technicians was $39,020 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $24,930, and the top 10 percent earned more than $62,890.

Median annual wages in selected industries employing biological technicians in May 2010 were as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Median Annual Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colleges, universities, and professional schools; private</td>
<td>$44,950</td>
</tr>
<tr>
<td>Pharmaceutical and medicine manufacturing</td>
<td>$43,010</td>
</tr>
<tr>
<td>Research and development in the physical, engineering, and life sciences</td>
<td>$42,280</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state</td>
<td>$38,480</td>
</tr>
<tr>
<td>Federal government, excluding postal service</td>
<td>$32,350</td>
</tr>
</tbody>
</table>
Most biological technicians work full time and keep regular hours.

**Job Outlook**
Employment of biological technicians is projected to increase 14 percent from 2010 to 2020, as fast as the average for all occupations. Greater demand for biotechnology research is expected to increase the need for these workers. Biotechnology research plays a key role in scientific advancements that improve our way of life. Biological technicians will be needed to help scientists develop new medicines and treatments for diseases such as cancer and Alzheimer’s. In agriculture, biotechnology research will be used to create genetically engineered crops that provide greater yields and require less pesticide and fertilizer. In addition, efforts to discover new and improved ways to clean and preserve the environment will continue to add to job growth. Finally, biological technicians will be needed to help develop alternative sources of energy, such as biofuels and biomass. Strong competition for jobs is expected. There have been large increases in the number of bachelor’s degrees in biology and other life sciences awarded each year, and this trend is expected to continue. Applicants who have laboratory experience, either through coursework or previous work experience, should have the best opportunities.


**Conservation Scientists and Foresters**

**What Conservation Scientists and Foresters Do**
Conservation scientists and foresters manage overall land quality of forests, parks, rangelands, and other natural resources.

Duties:
- Monitor forestry and conservation activities to assure compliance with government regulations
- Establish plans for managing forest lands and resources
- Supervise activities of other forestry and conservation workers
- Choose and prepare sites for new trees using controlled burning, bulldozers, or herbicides to clear land
- Negotiate terms and conditions for forest harvesting and land-use contracts
- Direct and participate in forest-fire suppression
- Determine ways to remove timber with minimum environmental damage
- Monitor forest-cleared lands to ensure that they are suitable for future use

Conservation scientists manage, improve, and protect the country's natural resources. They work with landowners and federal, state, and local governments to devise ways to use and improve the land while safeguarding the environment. Conservation scientists advise farmers, farm managers, and ranchers on how they can improve their land for agricultural purposes and control erosion. Foresters have a wide range of duties, and their responsibilities vary depending on their employer.
Some primary duties of foresters include drawing up plans to regenerate forested lands, monitoring the progress of those lands, and supervising tree harvests. They also come up with plans to keep forests free from disease, harmful insects, and damaging wildfires. Foresters may choose and direct the preparation of sites on which trees will be planted. They advise on the type, number, and placement of trees to be planted. When the trees reach a certain size, foresters decide which trees should be harvested and sold to sawmills. Many conservation scientists and foresters supervise forest and conservation workers and technicians, directing their work and evaluating their progress.

Conservation scientists and foresters evaluate data on forest and soil quality, assessing damage to trees and forest lands caused by fires and logging activities. In addition, they lead activities such as fire suppression and planting seedlings. Fire suppression activities include measuring how quickly fires will spread and how successful the planned suppression activity turns out. Scientists and foresters use their skills to determine a fire’s impact on a region’s environment. Communication with firefighters and other forest workers is an important component of fire suppression activities because the information that conservation scientists and foresters give can change how firefighters work.

Conservation scientists and foresters use a number of tools to perform their jobs. They use clinometers to measure the heights of trees, diameter tapes to measure a tree’s circumference, and increment borers and bark gauges to measure the growth of trees so that timber volumes can be computed and growth rates estimated. In addition, conservation scientists and foresters often use remote sensing (aerial photographs and other imagery taken from airplanes and satellites) and geographic information systems (GIS) data to map large forest or range areas and to detect widespread trends of forest and land use. They make extensive use of hand-held computers and global positioning systems (GPS) to study these maps.

The following are some types of conservation scientists and foresters:

- **Procurement foresters** buy timber by contacting local forest owners and negotiating a sale. This activity typically involves taking inventory on the type, amount, and location of all standing timber on the property. Procurement foresters then appraise the timber’s worth, negotiate its purchase, and draw up a contract. The forester then subcontracts with loggers or pulpwood cutters to remove the trees and to help lay out roads to get to the timber. Other foresters, mostly in the federal government, study issues facing forests and related natural resources. They may study issues such as tree improvement and harvesting techniques, global climate change, improving wildlife habitats, and protecting forests from pests, diseases, and wildfires.

- **Urban foresters** live and work in larger cities and manage urban trees. They are concerned with quality-of-life issues, including air quality, shade, and storm water runoff.

- **Conservation education foresters** train teachers and students about issues facing forest lands.

Two of the most common types of conservation scientists are range managers and soil conservationists.

- **Range managers**, also called range conservationists, protect rangelands to maximize their use without damaging the environment. Rangelands contain many natural resources and cover hundreds of millions of acres in the United States, mainly in the western states.
and Alaska. Range managers may inventory soils, plants, and animals; develop resource management plans; help to restore degraded ecosystems; or help manage a ranch. They also maintain soil stability and vegetation for uses such as wildlife habitats and outdoor recreation. Like foresters, they work to prevent and reduce wildfires and invasive animal species.

- **Soil and water conservationists** give technical help to people who are concerned with the conservation of soil, water, and related natural resources. For private landowners, they develop programs to make the most productive use of land without damaging it. They also help landowners with issues such as dealing with erosion. They help private landowners and governments by advising on water quality, preserving water supplies, preventing groundwater contamination, and conserving water.

How to Become a Conservation Scientist or Forester

Conservation scientists and foresters typically need a bachelor’s degree in forestry or a related field, such as agricultural science, rangeland management, or environmental science. Although graduate work is not generally required, some conservation scientists and foresters get a master’s degree or Ph.D. Many colleges and universities offer degrees in forestry or a related field. Bachelor’s degree programs are designed to prepare conservation scientists and foresters for their career or a graduate degree. Alongside practical skills, theory and education are important parts of these programs. Courses for bachelor’s and advanced degree programs in forestry and related fields typically include ecology, biology, and forest resource measurement. Scientists and foresters also typically have a background in a geographic information system (GIS) technology and other forms of computer modeling.

Many conservation scientists and foresters advance to take on managerial duties. They also may conduct research or work on policy issues, often after getting an advanced degree. Foresters in management usually leave fieldwork behind, spending more of their time in an office, working with teams to develop management plans and supervising others. One option for advancement in these occupations is to become certified. The Society of American Foresters certifies foresters who have at least a bachelor’s degree from one of the 50 forestry or natural resources degree programs accredited by the society or from a forestry program that is substantially equivalent. The candidate must also have 5 years of qualifying professional experience and pass an exam. The Society for Range Management also offers a professional certification in rangeland management or range management consultant. Soil conservationists usually begin working within one district and may advance to a state, regional, or national level. Also, soil conservationists can transfer to occupations such as farm or ranch management advisor or land appraiser.

Important Qualities:

- **Analytical skills.** Conservation scientists and foresters must evaluate the results of a variety of field tests and experiments, all of which require precision and accuracy.

- **Critical-thinking skills.** Conservation scientists and foresters reach conclusions through sound reasoning and judgment. They determine how to improve forest conditions, and they must react appropriately to fires.

- **Decision-making skills.** Conservation scientists and foresters must use their expertise and experience to determine whether their findings will have an impact on soil, forest lands, and the spread of fires.
- **Interpersonal skills.** Conservation scientists and foresters need to work well with the forest and conservation workers and technicians they supervise, so effective communication is critical.
- **Physical stamina.** Conservation scientists and foresters often walk long distances in steep and wooded areas. They work in all kinds of weather, including extreme heat and cold.
- **Speaking skills.** Conservation scientists and foresters must give clear instructions to forest and conservation workers and technicians, who typically do the labor necessary for proper forest maintenance.

**Pay**

The median annual wage of conservation scientists was $59,310 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $36,050, and the top 10 percent earned more than $89,440.

The median annual wage of foresters was $54,540 in May 2010. The lowest 10 percent earned less than $35,670, and the top 10 percent earned more than $75,540.

Median annual wages in the industries employing the largest number of conservation scientists in May 2010 were as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Median Annual Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government, excluding postal service</td>
<td>$71,100</td>
</tr>
<tr>
<td>Management, scientific, and technical consulting services</td>
<td>$63,310</td>
</tr>
<tr>
<td>Social advocacy organizations</td>
<td>$51,710</td>
</tr>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$51,270</td>
</tr>
<tr>
<td>Local government, excluding education and hospitals</td>
<td>$49,860</td>
</tr>
</tbody>
</table>

Median annual wages in the industries employing the largest number of foresters in May 2010 were as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Median Annual Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government, excluding postal service</td>
<td>$61,680</td>
</tr>
<tr>
<td>Logging</td>
<td>$59,830</td>
</tr>
<tr>
<td>Sawmills and wood preservation</td>
<td>$56,880</td>
</tr>
<tr>
<td>Local government, excluding education and hospitals</td>
<td>$53,150</td>
</tr>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$49,710</td>
</tr>
</tbody>
</table>

Most conservation scientists and foresters work full time and have a routine work schedule. Responding to emergencies or fires may require conservation scientists and foresters to work longer hours.

**Job Outlook**

Employment of conservation scientists and foresters is expected to increase by 5 percent between 2010 and 2020, slower than the average for all occupations. Heightened demand for American timber and wood pellets will help increase the overall job prospects for conservation scientists.
and foresters. Most growth from 2010 to 2020 for conservation scientists and foresters is expected to be in federally owned forest lands, particularly in the southwestern United States. Jobs in private forests will grow alongside demand for timber and pellets, but ongoing fiscal crises will likely lessen the number of available positions in state and local governments. In recent years, preventing and suppressing wildfires has become the primary concern for government agencies managing forests and rangelands. The development of previously unused lands, in addition to changing weather conditions, has contributed to increasingly devastating and costly fires. Increases in funding and new programs should create opportunities for foresters and range managers. Restoring lands affected by fires also will be a major task, particularly in the southwestern and western states, where such fires are most common.


**Dietitians and Nutritionists**

**What Dietitians and Nutritionists Do**

Dietitians and nutritionists are experts in food and nutrition. They advise people on what to eat in order to lead a healthy lifestyle or achieve a specific health-related goal.

**Duties:**

- Explain nutrition issues
- Assess patients’ and clients’ health needs and diet
- Develop meal plans, taking both cost and clients’ preferences into account
- Evaluate the effects of meal plans and change the plans as needed
- Promote better nutrition by giving talks to groups about diet, nutrition, and the relationship between good eating habits and preventing or managing specific diseases
- Keep up with the latest nutritional science research

Some dietitians and nutritionists provide customized information for specific individuals. For example, a dietitian or nutritionist might teach a patient with high blood pressure how to use less salt when preparing meals. Others work with groups of people who have similar needs. A dietitian or nutritionist might, for example, plan a diet with reduced fat and sugar to help overweight people lose weight.

Although all dietitians and nutritionists do similar tasks, there are several specialties within the occupations. The following are examples of types of dietitians and nutritionists:

- **Clinical dietitians** provide medical nutrition therapy. They work in hospitals, long-term care facilities, and other institutions. They create both individualized and group nutritional programs based on the health needs of patients or residents. Clinical dietitians may further specialize, such as working only with patients with kidney diseases. They may work with other health care professionals.

- **Management dietitians** plan meal programs. They work in food service settings such as cafeterias, hospitals, and food corporations. They may be responsible for buying food and for carrying out other business-related tasks. Management dietitians may oversee kitchen staff or other dietitians.
Community dietitians educate the public on topics related to food and nutrition. They often work with specific groups of people, such as pregnant women. They work in public health clinics, government and non-profit agencies, health maintenance organizations (HMOs), and other settings.

How to Become a Dietitian or Nutritionist

Most dietitians and nutritionists have earned a bachelor’s degree in dietetics, foods and nutrition, food service systems management, or a related area. Programs include courses in nutrition, physiology, chemistry, and biology.

Dietitians and nutritionists typically participate in several hundred hours of supervised training, usually in the form of an internship following graduation from college. However, some programs in dietetics include this training as part of the coursework. Many dietitians and nutritionists have advanced degrees. Most states require licensure of dietitians and nutritionists. Other states require only state registration or certification, and a few have no state regulations.

Most states have enacted state licensure or certification for dietitians or nutritionists or both. The requirements for state licensure and state certification include having a bachelor’s degree in food and nutrition or a related area, supervised practice, and passing an exam. One way to become licensed is to earn the Registered Dietitian (RD) credential. While the RD is not always required, the qualifications necessary to become an RD are parallel to the qualifications necessary to become a licensed dietitian in all states that require a license. Many employers prefer or require the RD, which is administered by the Commission on Dietetic Registration, the credentialing agency for the Academy of Nutrition and Dietetics. The requirements for the RD credential are similar, but not identical to the licensing requirements in many states. The RD requires dietitians to complete education and supervised practice programs. These programs are accredited by the Accreditation Council for Education in Nutrition and Dietetics (ACEND). In order to maintain the RD credential, Registered Dietitians must complete continuing professional education courses.

Important Qualities:

- **Analytical skills.** Dietitians must keep up to date with the latest nutrition research. They should be able to interpret scientific studies and translate nutrition science into practical eating advice.
- **Organizational skills.** Because there are many aspects to the work of dietitians and nutritionists, they should have the ability to stay organized. Management dietitians, for example, must consider both the nutritional needs of their customers and the costs of meals.
- **People skills.** Dietitians and nutritionists must listen carefully to understand clients’ goals and concerns. They also have to be emphatic to help clients confront and overcome dietary struggles.
- **Speaking skills.** Dietitians and nutritionists must explain complicated topics in a way that people with less technical knowledge understand. For example, a clinical dietitian must be able to clearly tell clients about what to eat and why eating the recommended foods is important.

Pay
The median annual wage of dietitians and nutritionists was $53,250 in May 2010. The median annual wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $33,330, and the top 10 percent earned more than $75,480. Most dietitians and nutritionists work full time, although about 20 percent work part time. Self-employed, consultant dietitians have more flexibility in setting their schedules.

Job Outlook
Employment of dietitians and nutritionists is expected to increase 20 percent from 2010 to 2020, faster than average for all occupations. In recent years, there has been increased interest in the role of food in promoting health and wellness, particularly as a part of preventative healthcare in medical settings. The importance of diet in preventing and treating illnesses such as diabetes and heart disease is now well known. More dietitians and nutritionists will be needed to provide care for people with these conditions. An aging population also will increase the need for dietitians and nutritionists in nursing homes.


Environmental Engineers

What Environmental Engineers Do
Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They are involved in efforts to improve recycling, waste disposal, public health, and control of water and air pollution. They also address global issues, such as safe drinking water, climate change, and sustainability.

Duties:
- Environmental engineers typically do the following:
- Prepare, review, and update environmental investigation reports
- Design projects leading to environmental protection, such as water reclamation facilities, air pollution control systems, and operations that convert waste to energy
- Obtain, update, and maintain plans, permits, and standard operating procedures
- Provide technical support for environmental remediation projects and legal actions
- Analyze scientific data and do quality-control checks
- Monitor progress of environmental improvement programs
- Inspect industrial and municipal facilities and programs to ensure compliance with environmental regulations
- Advise corporations and government agencies about procedures for cleaning up contaminated sites

Environmental engineers conduct hazardous-waste management studies in which they evaluate the significance of the hazard and advise on treating and containing it. They also design municipal water supply and industrial wastewater treatment systems and research the environmental impact of proposed construction projects. Environmental engineers in government develop regulations to prevent mishaps. Some environmental engineers study ways to minimize the effects of acid rain, global warming, automobile emissions, and ozone depletion. They also
collaborate with environmental scientists, planners, hazardous waste technicians, engineers, and other specialists, such as experts in law and business, to address environmental problems and sustainability.

How to Become an Environmental Engineer
Students interested in studying environmental engineering should take high school courses in chemistry, biology, physics, and mathematics, including algebra, trigonometry, and calculus. Entry-level environmental engineering jobs require a bachelor's degree. Bachelor's degree programs typically last 4 years and include classroom, laboratory, and field studies. Some colleges and universities offer cooperative programs where students gain practical experience while completing their education. At some colleges and universities, a student can enroll in a 5-year program that leads to both a bachelor’s and a master's degree. A graduate degree allows an engineer to work as an instructor at some colleges and universities or to do research and development. Many engineering programs are accredited by ABET (formerly the Accreditation Board for Engineering and Technology). Some employers prefer to hire candidates who have graduated from an accredited program. A degree from an ABET-accredited program is usually necessary to become a licensed professional engineer.

Important Qualities:

- **Communication skills.** Environmental engineers must be able to write clearly so others without their specific training understand their plans, proposals, specifications, findings, and other documents.
- **Problem-solving skills.** When designing facilities and processes for treating wastewater and other pollution, environmental engineers strive to solve several issues at once, from workers’ safety to environmental protection. They must be able to identify and anticipate problems to prevent losses for their employers, safeguard workers’ health, and mitigate environmental damage.
- **Reading-comprehension skills.** Environmental engineers often work with business people, lawyers, and other professionals outside their field. They often are required to read and understand documents that are outside their scope of training.
- **Systems analysis.** Environmental engineers sometimes have to design systems that will be part of larger ones. They must be able to foresee how the proposed designs will interact with other components in the process, including the workers, machinery, equipment, or the environment.
- **Teamwork.** Environmental engineers must be able to work with others toward a common goal. They usually work with engineers and scientists who design other systems and with the technicians and mechanics that put the designs into practice.

Environmental engineers are encouraged to obtain a professional engineer (PE) license. Licensure generally requires the following:

- A degree from an engineering program accredited by ABET
- A passing score on the Fundamentals of Engineering (FE) exam
- Relevant work experience
- A passing score on the Professional Engineering (PE) exam
The initial Fundamentals of Engineering (FE) exam can be taken after graduation. Engineers who pass this exam are commonly called engineers in training (EITs) or engineer interns (EIs). After getting suitable work experience, EITs can take the second exam, called the Principles and Practice of Engineering. Several states require continuing education for engineers to keep their license. Most states recognize licensure from other states, if the licensing state’s requirements meet or exceed their own requirements. After licensing, environmental engineers can earn certification known as Board Certified from the American Academy of Environmental Engineers. This certification is similar to that for physicians and shows that an environmental engineer has expertise in one or more areas of specialization. As beginning engineers gain knowledge and experience, they move on to more difficult projects, and they have greater independence to develop designs, solve problems, and make decisions. Eventually, environmental engineers may advance to become technical specialists or to supervise a team of engineers and technicians. Some may even become engineering managers or move into executive positions, such as program managers. However, before assuming a managerial position, an engineer usually works under the supervision of a more experienced engineer.

Pay
The median annual wage of environmental engineers was $78,740 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $48,980, and the top 10 percent earned more than $119,060.

Median annual wages in the industries employing the largest numbers of environmental engineers in May 2010 were the following:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Annual Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government, excluding postal service</td>
<td>$100,270</td>
</tr>
<tr>
<td>Architectural, engineering, and related services</td>
<td>$78,450</td>
</tr>
<tr>
<td>Local government, excluding education and hospitals</td>
<td>$75,280</td>
</tr>
<tr>
<td>Management, scientific, and technical consulting services</td>
<td>$74,940</td>
</tr>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$69,050</td>
</tr>
</tbody>
</table>

Most environmental engineers work full time. Those who manage projects often work more than 40 hours per week.

Job Outlook
Employment of environmental engineers is projected to grow 22 percent from 2010 to 2020, faster than the average for all occupations. State and local governments’ concerns about water are leading to efforts to increase the efficiency of water use. This focus differs from that of wastewater treatment, for which this occupation is traditionally known. The requirement by the federal government to clean up contaminated sites is expected to help sustain demand for these engineers’ services. Additionally, wastewater treatment is becoming a larger concern in areas of the country where new methods of drilling for shale gas require the use and disposal of massive volumes of water. Environmental engineers will continue to be needed to help utilities and water
treatment plants comply with any new federal or state environmental regulations. All levels of
government must comply with environmental regulations, especially federal. Because of this,
employment of environmental engineers within the government sector as a whole should remain
relatively stable through the year 2020.

13 Edition*, Environmental Engineers, on the Internet at http://www.bls.gov/ooh/architecture-

**Environmental Scientists**

**What Environmental Scientists Do**

Environmental scientists and specialists use their knowledge of the natural sciences to protect the
environment. They identify problems and find solutions that minimize hazards to the health of
the environment and the population.

**Duties:**

- Determine data collection methods for research projects, investigations, and surveys
- Collect environmental data, such as samples of air, soil, water, food, and other materials, for scientific analysis
- Analyze samples, surveys, and other information to identify and assess threats to the environment
- Develop plans to prevent, control, or fix environmental problems, such as pollution and harm to land or water
- Develop plans to restore polluted or contaminated land or water
- Provide information and guidance to government officials, businesses, and the general public on possible environmental hazards and health risks
- Prepare technical reports and presentations that explain their research and findings

Environmental scientists and specialists analyze environmental problems and develop solutions. For example, many environmental scientists and specialists work to reclaim lands and waters that have been contaminated by pollution. Others assess the risks new construction projects pose to the environment and make recommendations to governments and businesses on how to minimize the environmental impact of these projects. They also identify ways that human behavior can be changed to avoid problems such as the depletion of the ozone layer.

The federal government and many state and local governments have regulations to ensure that there is clean air to breathe, safe water to drink, and no hazardous materials in the soil. The regulations also place limits on development, particularly near sensitive parts of the ecosystem, such as wetlands. Many environmental scientists and specialists work for the government to ensure that these regulations are followed. Other environmental scientists work for consulting firms that help companies comply with regulations and policies.

Some environmental scientists and specialists focus on environmental regulations that are designed to protect people’s health, while others focus on regulations designed to minimize society’s impact on the ecosystem.

The following are examples of types of specialists:
• **Environmental health specialists** study how environmental factors impact human health. They investigate potential health risks, such as unsafe drinking water, disease, and food safety. They also educate the public about potential health risks present in the environment.

• **Environmental protection specialists** monitor the effect human activity has on the environment. They investigate sources of pollution and develop prevention, control, and remediation plans.

• **Other environmental scientists** do work and receive training that is similar to that of other physical or life scientists, but they focus on environmental issues. Environmental chemists are an example.

• **Environmental chemists** study the effects that various chemicals have on ecosystems. For example, they look at how acids affect plants, animals, and people. Some areas in which they work include waste management and the remediation of contaminated soils, water, and air.

• Many people with backgrounds in environmental science become professors and teachers.

**How to become an Environmental Scientist**

For most jobs, environmental scientists and specialists need at least a bachelor’s degree in a natural science. For most entry-level jobs, environmental scientists and specialists must have a bachelor’s degree in environmental science or another natural science, such as biology, chemistry, or geosciences. However, a master’s degree may be needed for advancement. A doctoral degree is typically needed only for college teaching and some research positions. A bachelor’s degree in environmental science offers a broad approach to the natural sciences. Students typically take courses in biology, chemistry, geology, and physics. Students often take specialized courses in hydrology, waste management, and fluid mechanics as part of their degree as well. Classes in environmental policy and regulation are also beneficial. Students should look for opportunities, such as through classes and internships, to work with computer modeling, data analysis, and geographic information systems. Students with experience in these programs will be the best prepared to enter the job market.

**Important Qualities:**

- **Analytical skills.** Environmental scientists and specialists base their conclusions on careful analysis of scientific data. They must consider all possible methods and solutions in their analyses.

- **Interpersonal skills.** Environmental scientists and specialists typically work on teams with scientists, engineers, and technicians. Team members must be able to work together effectively to achieve their goals.

- **Problem-solving skills.** Environmental scientists and specialists try to find the best possible solution to problems that affect the environment and people’s health.

- **Speaking skills.** Environmental scientists and specialists often give presentations that explain their findings, and they need to convince others to accept their recommendations.

- **Writing skills.** Environmental scientists and specialists write technical reports that explain their methods, findings, and recommendations.

**Pay**
The median annual wage of environmental scientists and specialists was $61,700 in May 2011. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $37,850, and the top 10 percent earned more than $107,990. Most environmental scientists and specialists work full time. They may have to work long or irregular hours when working in the field.

**Job Outlook**

Employment of environmental scientists and specialists is expected to grow by 19 percent from 2010 to 2020, about as fast as the average for all occupations. Heightened public interest in the hazards facing the environment, as well as the increasing demands placed on the environment by population growth, is projected to spur demand for environmental scientists and specialists. Further demand is also expected as a result of new and increasingly complex environmental laws and regulations. Most employment growth for environmental scientists and specialists is projected to be in private consulting firms that help clients monitor and manage environmental concerns and comply with regulations. More businesses are expected to consult with environmental scientists in the future to help them minimize the impact their operations have on the environment. For example, environmental consultants help businesses develop practices that minimize waste, prevent pollution, and conserve resources. Other environmental scientists are expected to be needed to help planners develop and construct buildings, utilities, and transportation systems that protect natural resources and limit damage to the land.


**Forensic Science Technicians**

**What Forensic Science Technicians Do**

Forensic science technicians help investigate crimes by collecting and analyzing physical evidence. Most technicians specialize in either crime scene investigation or laboratory analysis. Duties:

At crime scenes, forensic science technicians, also known as *crime scene investigators*, typically do the following:

- Walk through the scene to determine what and how evidence should be collected
- Take photographs of the crime scene and evidence
- Make sketches of the crime scene
- Keep written notes of their observations and findings, such as the location and position of evidence as it is found
- Collect all relevant physical evidence, including weapons, fingerprints, and bodily fluids
- Catalog and preserve evidence before transferring it to a crime lab

Crime scene investigators may use tweezers, black lights, and specialized kits to identify and collect evidence. In addition to processing crime scenes, they may also attend autopsies.

In laboratories, forensic science technicians typically do the following:

- Identify and classify crime scene evidence through scientific analysis
Explore possible links between suspects and criminal activity using the results of chemical and physical analyses
Consult with experts in related or specialized fields, such as toxicology, about the evidence and their findings
Reconstruct crime scenes based on scientific findings

Forensic science technicians reconstruct crime scenes by carefully studying information gathered by investigators and conducting scientific tests on physical evidence. For example, lab technicians may look at photographs of blood splatter patterns and conduct ballistics tests on bullets found at the crime scene to determine the direction from which a shot was fired. Forensic science technicians who work in laboratories use chemicals and laboratory equipment such as microscopes when analyzing evidence. They also use computer databases to examine fingerprints, DNA, and other evidence collected at crime scenes in order to match them to people and things that have already been identified. Most forensic science technicians who perform laboratory analysis specialize in a specific type of evidence analysis, such as DNA or ballistics. All forensic science technicians prepare written reports that detail their findings and investigative methods. They must be able to explain their reports to lawyers, detectives, and other law enforcement officials. In addition, forensic science technicians may be called to testify in court about their findings and methods.

How to Become a Forensic Science Technician
The educational requirements for crime scene investigators vary by employer. Forensic science technicians need a bachelor’s degree to work in crime labs. Extensive amounts of on-the-job training are required for both those who investigate crime scenes and those who work in labs. Many crime scene investigators are sworn police officers and have met educational requirements necessary for admittance to the police academy. Applicants for non-uniform crime scene investigator jobs at larger law enforcement agencies should have a bachelor’s degree in either forensic science or a natural science, but many rural agencies hire applicants with a high school diploma. For more information on police officers, see the profile on police and detectives. Technicians who work in crime laboratories typically need a bachelor’s degree in either forensic science or a natural science such as biology or chemistry. Students who major in forensic science should ensure that their program includes extensive course work in mathematics, chemistry, and biology. A list of schools that offer degrees in forensic science is available from the American Academy of Forensic Sciences.

Important Qualities:
- **Composure.** Crime scenes can be gruesome, but technicians have to maintain their professionalism.
- **Critical-thinking skills.** Forensic science technicians use their best judgment when matching physical evidence, such as fingerprints and DNA, to suspects.
- **Detail oriented.** Forensic science technicians cannot afford to make mistakes when they collect and analyze evidence.
- **Problem-solving skills.** Forensic science technicians use scientific tests and methods to help law enforcement officials solve crimes.
Speaking skills. Forensic science technicians frequently present their findings to police and other law enforcement workers. They may be called upon to provide expert testimony in a court of law.

Writing skills. Forensic science technicians prepare written reports that must stand up to legal scrutiny.

Forensic science technicians need extensive on-the-job training before they are ready to work on cases independently. Newly hired crime scene investigators serve as apprentices to more experienced investigators. During their apprenticeship, investigators learn proper procedures and methods for collecting and documenting evidence.

Forensic science technicians learn laboratory specialties on the job. The length of this training varies by specialty. Most DNA-analysis training programs last 6 to 12 months, but firearms-analysis training may last up to 3 years. Technicians need to pass a proficiency exam before they may perform independent casework or testify in court.

Throughout their careers, forensic science technicians need to keep abreast of advances in technology and science that improve the collection or analysis of evidence.

Pay
The median annual wage of forensic science technicians was $51,570 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $32,900, and the top 10 percent earned more than $82,990.

Crime scene investigators work staggered day, evening, or night shifts and may have to work overtime because they must always be available to collect evidence. Technicians working in laboratories usually work a standard workweek, although they may have to be on call outside of normal business hours if they are needed to work immediately on a crime scene.

Job Outlook
Employment of forensic science technicians is projected to grow by 19 percent from 2010 to 2020, about as fast as the average for all occupations. Technological advances and the growing awareness of forensic evidence among potential jurors are expected to increase the use of forensic evidence in criminal proceedings. More forensic science technicians will be needed to provide timely forensics information to law enforcement agencies and courts.

Competition for jobs should be stiff because of the substantial interest in forensic science and crime scene investigation spurred by its portrayal in popular media. Applicants with experience or a bachelor’s degree in forensic science or a related field should have the best opportunities.

Year to year, the number of job openings available will vary based on federal, state, and local law enforcement budgets.


Medical Laboratory Technologists
What Medical Laboratory Technologists Do
Medical laboratory technologists (also known as medical laboratory scientists) and medical laboratory technicians collect samples and perform the tests to analyze body fluids, tissue, and other substances.

Duties:
- Analyze body fluids such as blood, urine, and tissue samples to determine normal or abnormal findings
- Collect and study blood samples for use in transfusions by identifying the number of cells, the cell morphology or the blood group, blood type, and compatibility with other blood types
- Operate sophisticated laboratory equipment such as microscopes and cell counters
- Use automated equipment and computerized instruments capable of performing a number of tests at the same time
- Log data from medical tests and enter results into a patient’s medical record
- Discuss results and findings of laboratory tests and procedures with physicians
- Supervise or train medical laboratory technicians

Medical laboratory technicians usually work under the supervision of medical laboratory technologists or laboratory managers. Both technicians and technologists perform tests and procedures that physicians or other healthcare personnel order. However, technologists perform more complex tests and laboratory procedures than technicians do. For example, technologists may prepare specimens and operate automated analyzers or perform manual tests that are based on detailed instructions.

Technologists in small laboratories perform many types of tests; in large laboratories, they generally specialize. The following are examples of types of specialized medical laboratory technologists:
- **Blood bank technologists**, or **immunohematology technologists**, collect blood, classify it by type, and prepare blood and its components for transfusions.
- **Clinical chemistry technologists** prepare specimens and analyze the chemical and hormonal contents of body fluids.
- **Cytotechnologists** prepare slides of body cells and examine these cells with a microscope for abnormalities that may signal the beginning of a cancerous growth.
- **Immunology technologists** examine elements of the human immune system and its response to foreign bodies.
- **Microbiology technologists** examine and identify bacteria and other microorganisms.
- **Molecular biology technologists** perform complex protein and nucleic acid tests on cell samples. Like technologists, medical laboratory technicians may work in several areas of the laboratory or specialize in one particular area.
- **Phlebotomists** collect blood samples.
- **Histotechnicians** cut and stain tissue specimens for pathologists, doctors who study cause and development of diseases at a microscopic level.

How to Become Medical Laboratory Technologist
Medical laboratory technologists typically need a bachelor’s degree. Technicians usually need an associate’s degree or a postsecondary certificate. Some states require technologists and technicians to be licensed.
High school students who are interested in pursuing a career in the medical laboratory sciences should take courses in chemistry, biology, and mathematics. Universities and hospitals offer medical technology programs. An entry-level job for technologists usually requires a bachelor's degree in medical technology or life sciences. A bachelor’s degree in medical laboratory technology includes courses in chemistry, biology, microbiology, mathematics, and statistics, as well as courses on clinical laboratory skills, management, and education. This degree is sometimes known as a medical laboratory scientist program.

The courses may be offered through a hospital-based program that students attend during their senior year of college. College graduates who major in other sciences and meet a program’s prerequisites, such as having completed required courses in biology and chemistry, may also apply to a medical laboratory science program.

Prospective medical laboratory technicians must complete an associate’s degree program that includes science and clinical laboratory science courses. Often, 1-year certificate programs are available from hospitals for those who already have a degree in a related field, such as nursing. The Armed Forces and vocational or technical schools may also offer certificate programs for medical laboratory technicians. The technician coursework addresses the theoretical and practical aspects of each of the major laboratory disciplines, but the courses are not as in-depth as those that technologists take.

Some states require laboratory personnel to be licensed or registered. To be licensed, a technologist often needs a bachelor's degree and must pass an exam. However, requirements vary by state and specialty. For specific requirements, contact your state’s department of health or board of occupational licensing. Certification of medical laboratory technologists and technicians is required for licensure in some states and by some individual employers. Although certification is not required to enter the occupation in all cases, employers typically prefer to hire certified technologists and technicians. Medical laboratory technologists and technicians can obtain a general certification as a medical laboratory technologist or technician, or a certification in a specialty, such as phlebotomy or medical biology. Most credentials require that technologists complete an accredited education program to qualify to sit for an examination. Continuing education is required in most cases to maintain certification.

Important Qualities:

- **Compassion.** Medical laboratory technologists and technicians need to be empathetic while completing challenging tasks. They work closely with patients who may be in extreme pain or emotional stress and whose cooperation they must be able to get.

- **Detail oriented.** Medical laboratory technologists and technicians must follow exact instructions from physicians in order to perform the correct tests or procedures.

- **Dexterity.** Medical laboratory technologists and technicians require skill while working with their hands. They work closely with needles and precise laboratory instruments and must be able to handle these tools effectively.

- **Stamina.** Medical laboratory technologists and technicians may work on their feet for long periods while collecting samples. They may need to lift or turn disabled patients to collect samples for testing.

- **Technical skills.** Medical laboratory technologists and technicians must understand how to operate complex machinery.
Pay
The median annual wage of medical laboratory technologists was $56,130 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned more than $38,810, and the highest 10 percent earned more than $76,780.
The median annual wages in selected industries employing medical laboratory technologists in May 2010 were as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government</td>
<td>$62,880</td>
</tr>
<tr>
<td>Hospitals; state, local, and private</td>
<td>56,470</td>
</tr>
<tr>
<td>Medical and diagnostic laboratories</td>
<td>55,930</td>
</tr>
<tr>
<td>Offices of physicians</td>
<td>52,250</td>
</tr>
</tbody>
</table>

Job Outlook
Employment of medical laboratory technologists is expected to grow by 11 percent between 2010 and 2020, about as fast as the average for all occupations. Employment of medical laboratory technicians is expected to grow by 15 percent between 2010 and 2020, about as fast as the average for all occupations. An increase in the aging population will lead to a greater need to diagnose medical conditions, such as cancer or type 2 diabetes, through laboratory procedures. Medical laboratory technologists and technicians will be needed to use and maintain the equipment needed for diagnosis and treatment.


Microbiologists

What Microbiologists Do
Microbiologists study the growth, development, and other characteristics of microscopic organisms such as bacteria, algae, and fungi.

Duties:
- Plan and conduct complex research projects, such as developing new drugs to combat infectious diseases
- Supervise the work of biological technicians and other workers and evaluate the accuracy of their results
- Isolate and maintain cultures of bacteria or other microorganisms for future study
- Identify and classify microorganisms found in specimens collected from humans, water, food, and other sources
- Monitor the effect of microorganisms on plants, animals, and other microorganisms and on the environment
- Keep up with findings from other research groups by reading research reports and attending conferences
• Prepare technical reports, research papers, and recommendations based on their research findings
• Present research findings to scientists, non-scientist executives, engineers, other colleagues, and the public

Most microbiologists work in research and development. Many conduct basic research with the aim of increasing scientific knowledge. Others conduct applied research, using knowledge from basic research to develop new products or solve particular problems. For example, microbiologists help to develop genetically engineered crops, biofuels, and ways to protect the environment.

Microbiologists use computers and a wide variety of sophisticated laboratory instruments to do their experiments and analyze the results. For example, microbiologists use powerful electron microscopes to study bacteria. They use advanced computer software to analyze the growth of microorganisms found in samples.

Most microbiologists work as part of a team. An increasing number of scientific research projects involve multiple disciplines, and it is common for microbiologists to work on teams with technicians and scientists in other fields.

For example, microbiologists researching new drugs may work with medical scientists and biochemists to develop new medicines such as antibiotics and vaccines. As another example, microbiologists in medical diagnostic laboratories work alongside physicians, nurses, medical laboratory technologists and technicians and other health professionals to help prevent, treat, and cure diseases.

The following are examples of types of microbiologists:

- **Bacteriologists** study the growth, development, and other properties of bacteria, including the positive and negative effects bacteria have on plants, animals, and humans.
- **Clinical microbiologists** study microorganisms that can cause, cure, or be used to treat diseases in humans.
- **Immunologists** study how organisms’ immune systems react to and defend against microorganisms.
- **Mycologists** study the properties of fungi such as yeast and mold, as well as the ways fungi can be used (for example, in food and medicine) to benefit society.
- **Virologists** study the structure, development, and other properties of viruses and any effects they would have on organisms they infect.
- Many people with a microbiology background become high school teachers or professors.

**How to Become a Microbiologist**

A bachelor’s degree in microbiology or a closely related field is needed for entry-level microbiologist jobs. A Ph.D. is needed to carry out independent research and to work in colleges and universities.

Microbiologists need at least a bachelor’s degree in microbiology or a closely related field such as biochemistry or cell biology. Many colleges and universities offer degree programs in biological sciences, including microbiology.

Most microbiology majors take introductory courses in microbial genetics and microbial physiology before taking classes in more advanced topics such as environmental microbiology and virology. Students also must take classes in other sciences, such as biochemistry, chemistry,
and physics, because it is important for microbiologists to have a broad understanding of the sciences. Courses in statistics, mathematics, and computer science are important for microbiologists because they must be able to do complex data analysis. It is important for prospective microbiologists to have laboratory experience before entering the workforce. Most undergraduate microbiology programs include a mandatory laboratory requirement, but additional laboratory coursework is recommended. Students also can gain valuable laboratory experience through internships with prospective employers such as drug manufacturers.

Microbiologists typically need a Ph.D. to carry out independent research and work in colleges and universities. Graduate students studying microbiology commonly specialize in a subfield such as bacteriology or virology. Ph.D. programs usually include class work, laboratory research, and completing a thesis or dissertation. It typically takes 4 to 6 years to complete a doctoral degree program in microbiology. Many microbiology Ph.D. holders begin their careers in a temporary postdoctoral research position, which typically lasts 2 to 3 years. During their postdoctoral appointment, they work with experienced scientists as they continue to learn about their specialties or develop a broader understanding of related areas of research. Postdoctoral positions typically offer the opportunity to publish research findings. A solid record of published research is essential to get a permanent position in basic research, especially a permanent faculty position in a college or university.

Important Qualities:

- **Analytical skills.** Microbiologists must be able to conduct scientific experiments and analyses with accuracy and precision.
- **Critical-thinking skills.** Microbiologists draw conclusions from experimental results through sound reasoning and judgment.
- **Interpersonal skills.** Microbiologists typically work on research teams and thus must work well with others toward a common goal. Many also lead research teams and must be able to motivate and direct other team members.
- **Mathematical skills.** Microbiologists regularly use complex mathematical equations and formulas in their work. Therefore, they need a broad understanding of mathematics, including calculus and statistics.
- **Observation skills.** Microbiologists must constantly monitor their experiments. They need to keep a complete, accurate record of their work such as conditions, procedures, and results.
- **Perseverance.** Microbiological research involves substantial trial and error, and microbiologists must not become discouraged in their work.
- **Problem-solving skills.** Microbiologists use scientific experiments and analysis to find solutions to complex scientific problems.
- **Speaking skills.** Microbiologists frequently give presentations and must be able to explain their research to others.
- **Writing skills.** Microbiologists write memos, reports, and research papers that explain their findings.
Microbiologists typically receive greater responsibility and independence in their work as they gain experience. They also gain greater responsibility through more education. Ph.D. microbiologists usually lead research teams and control the direction and content of projects. Some microbiologists move into managerial positions, often as natural sciences managers. Those who pursue management careers spend much of their time on administrative tasks such as preparing budgets and schedules.

**Pay**
The median annual wage of microbiologists was $65,920 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $39,180, and the top 10 percent earned more than $115,720.

Median annual wages in the industries employing the largest numbers of microbiologists in May 2010 were as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government, excluding postal service</td>
<td>$94,960</td>
</tr>
<tr>
<td>Research and development in the physical, engineering, and life sciences</td>
<td>$68,040</td>
</tr>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$63,950</td>
</tr>
<tr>
<td>Pharmaceutical and medicine manufacturing</td>
<td>$62,350</td>
</tr>
<tr>
<td>Colleges, universities, and professional schools; state</td>
<td>$49,360</td>
</tr>
</tbody>
</table>

Most microbiologists work full time and keep regular hours.

**Job Outlook**
Employment of microbiologists is projected to increase by 13 percent from 2010 to 2020, about as fast as the average for all occupations. More microbiologists will be needed to apply knowledge from basic research to develop biological products and processes that improve our lives.

The development of new medicines and treatments is expected to increase the demand for microbiologists in pharmaceutical and biotechnology research. Microbiologists will be needed to research and develop new medicines and treatments, such as vaccines and antibiotics that are used to fight infectious diseases. In addition, microbiologists will be needed to help pharmaceutical and biotechnology companies develop biological drugs that are produced with the aid of microorganisms.

Aside from improving our health, other areas of research and development in biotechnology are expected to provide employment growth for microbiologists. Greater demand for clean energy should increase the need for microbiologists who research and develop alternative energy sources such as biofuels and biomass. In agriculture, more microbiologists will be needed to help develop genetically engineered crops that provide greater yields and require less pesticide and fertilizer. Finally, efforts to discover new and improved ways to clean up and preserve the environment also will increase demand for microbiologists.
Most of the applied research projects that microbiologists are involved in require the expertise of scientists in multiple fields such as biochemistry, chemistry, and medicine. Microbiologists who have a broad understanding of microbiology and its relationship to other disciplines should have the best opportunities.

A large portion of basic research in microbiology depends on funding from the federal government through the National Institutes of Health and the National Science Foundation. Therefore, federal budgetary decisions will affect job prospects in basic research from year to year. Typically, there is strong competition among microbiologists for research funding.


**Zoologists and Wildlife Biologists**

**What Zoologists and Wildlife Biologists Do**

Zoologists and wildlife biologists study the characteristics and habitats of animals and wildlife. Duties:

- Develop and conduct experimental studies with animals in controlled or natural surroundings
- Collect biological data and specimens for further analysis
- Study the characteristics of animals, such as their interactions with other species, reproduction, diseases, and movement patterns
- Analyze the influence that human activity has on wildlife and their natural habitats
- Estimate wildlife populations
- Write research papers, reports, and scholarly articles that explain their findings
- Give presentations on research findings
- Make recommendations to policymakers and the general public on wildlife conservation and management issues

Zoologists and wildlife biologists perform a variety of scientific tests and experiments. For example, they take blood samples from animals to assess their levels of nutrition. Zoologists and wildlife biologists use geographic information systems, modeling software, and other computer programs to estimate populations and track the behavior patterns of animals. They also use these programs to forecast the spread of invasive species, diseases, and other potential threats to wildlife.

Zoologists and wildlife biologists conduct research for a variety of purposes. For example, many zoologists and wildlife biologists work to increase knowledge and understanding of wildlife species. They also work closely with public officials to develop wildlife management and conservation plans to ensure species are protected from threats and animal populations remain at sustainable levels.

Most zoologists and wildlife biologists work on research teams with other scientists and technicians. For example, zoologists and wildlife biologists may work with environmental scientists and hydrologists to monitor the effects of water pollution on fish populations. Many zoologists and wildlife biologists are identified by the types of species they study. The following are examples of those who specialize by species:
- **Entomologists** study insects.
- **Herpetologists** study reptiles and amphibians, such as snakes and frogs.
- **Ichthyologists** study fish.
- **Mammalogists** study mammals, such as monkeys and bears.
- **Ornithologists** study birds.

Some wildlife biologists study animals by where they live. The following are examples of those who specialize by habitat:

- **Marine biologists** study organisms that live in saltwater.
- **Limnologists** study organisms that live in freshwater.

Other zoologists and wildlife biologists are identified by the aspects of zoology and wildlife biology they study, such as evolution and animal behavior. The following are some examples:

- **Ecologists** study the ecosystem, which is the relationship between organisms and with the surrounding environment.
- **Evolutionary biologists** study the origins of species and the changes in their inherited characteristics over generations.

Many people with a zoology and wildlife biology background become high school teachers or professors.

**How to Become a Zoologist or Wildlife Biologist**

Zoologists and wildlife biologists need a bachelor’s degree for entry-level positions, but a master’s degree is often needed for advancement. A Ph.D. is necessary for independent research and for college teaching positions.

Zoologists and wildlife biologists need at least a bachelor’s degree. Many schools offer bachelor’s degree programs in zoology and wildlife biology or a closely related field such as ecology. An undergraduate degree in biology with coursework in zoology and wildlife biology is also good preparation for a career as a zoologist or wildlife biologist. Zoologists and wildlife biologists typically need at least a master’s degree for higher-level positions. A Ph.D. is necessary for most independent research and for college teaching positions.

Students typically take zoology and wildlife biology courses in ecology, anatomy, wildlife management, and cellular biology. They also take courses that focus on a particular group of animals, such as ichthyology (fish) or ornithology (birds). Courses in botany, chemistry, and physics are important because zoologists and wildlife biologists must have a well-rounded scientific background. Students should also take courses in mathematics and statistics because zoologists and wildlife biologists must be able to do complex data analysis.

Knowledge of computer science is important because zoologists and wildlife biologists frequently use advanced computer software, such as geographic information systems and modeling software, to do their work.

**Important Qualities:**

- **Critical-thinking skills.** Zoologists and wildlife biologists need sound reasoning and judgment to draw conclusions from experimental results and scientific observations.
- **Interpersonal skills.** Zoologists and wildlife biologists typically work on teams. They must be able to work effectively with others to achieve their goals.
- **Observation skills.** Zoologists and wildlife biologists must be able to notice slight changes in an animal’s characteristics, such as their behavior or appearance.
• **Problem-solving skills.** Zoologists and wildlife biologists try to find the best possible solutions to threats that affect wildlife, such as disease and habitat loss.

• **Speaking skills.** Zoologists and wildlife biologists often give presentations to colleagues, managers, policymakers, and the general public. They need to be able to educate others on wildlife conservation and management issues.

• **Writing skills.** Zoologists and wildlife biologists write scientific papers, reports, and articles that explain their findings.

Zoologists and wildlife biologists typically receive greater responsibility and independence in their work as they gain experience. More education can also lead to greater responsibility. Zoologists and wildlife biologists with a Ph.D. usually lead research teams and control the direction and content of projects.

**Pay**
The median annual wage of zoologists and wildlife biologists was $57,430 in May 2010. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $35,660, and the top 10 percent earned more than $93,450.

Median annual wages in the industries employing the largest numbers of zoologists and wildlife biologists in May 2010 were:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal government, excluding postal service</td>
<td>$71,110</td>
</tr>
<tr>
<td>Research and development in the physical, engineering, and life sciences</td>
<td>$63,740</td>
</tr>
<tr>
<td>State government, excluding education and hospitals</td>
<td>$52,360</td>
</tr>
<tr>
<td>Management, scientific, and technical consulting services</td>
<td>$50,040</td>
</tr>
</tbody>
</table>

Most zoologists and wildlife biologists work full time. They may work long or irregular hours when doing fieldwork.

**Job Outlook**
Employment of zoologists and wildlife biologists is projected to grow by 7 percent from 2010 to 2020, slower than the average for all occupations. More zoologists and wildlife biologists will be needed to study the impact of population growth and development on wildlife and their habitats. However, demand for zoologists and wildlife biologists in local, state, and federal government agencies, such as the United States Fish and Wildlife Service, will vary based on the budgets for these agencies.

As the population grows and expands into new areas it will expose wildlife to threats such as disease, invasive species, and habitat loss. Increased human activity causes problems, such as pollution and climate change, that endanger wildlife. For example, changes in climate patterns can be detrimental to the migration habits of animals, and increased sea levels can destroy wetlands. Zoologists and wildlife biologists will be needed to research, develop, and carry out
wildlife management and conservation plans that combat these threats and protect our biological resources.

Zoologists and wildlife biologists should have good job opportunities. In addition to job growth, many job openings will be created by zoologists and wildlife biologists who retire, advance to management positions, or change careers.

Year to year, the number of job openings available in local, state, and federal government agencies, such as the United States Fish and Wildlife Service, will vary based on the budgets for these agencies.