

DEPARTMENT OF BIOLOGY

Department Chair: Sean Ryan, Ph.D.

Faculty

K. Altman, Ph.D.
 J. Benington, Ph.D.
 K. Dykstra, Ph.D.
 S. Jodush, M.S.
 R. Knittel, M.S.
 S. Ryan, Ph.D.
 Fr. P. Schneible, O.F.M., Ph.D.
 J. Schwingel, Ph.D.
 K. Vogel, M.S.
 X. Zhang, Ph.D.

Department Learning Goals:

1. Students will comprehend, connect, and evaluate concepts and modes of inquiry in biology.
2. Students will master a set of laboratory skills common to biology, and demonstrate the ability to use these skills in the planning and execution of a scientific study.
3. Students will develop a working knowledge of the core concepts of the physical sciences and mathematics in order to apply them to their developing understanding of biology.
4. Students will complete one or more projects which integrate and apply their undergraduate education in a professional context.

The objectives of the department of biology are to provide the student with opportunities to obtain a broad foundation of biological knowledge and to pursue the study of a particular area of biology through upper-division coursework and mentored research. The curriculum is based strongly in the sciences of biology, chemistry and physics, within the context of the critical and analytic skills derived from the liberal arts core.

The specific aims of the department of biology are

1. to provide an intensive course of study in the biological sciences;
2. to develop in the majors an appreciation for critical scientific work;
3. to present a program of study which reflects current thinking in the rapidly expanding field of biology.

After successful completion of the program a student may enter any of several career paths. The biology curriculum prepares a student for graduate school, laboratory work and teaching. It also provides all the requirements for application to medical, dental, veterinary and many other health-related programs.

Dr. Arnold T. Borer Summer Research Program

The department of biology at St. Bonaventure offers summer research opportunities in the areas of cellular and molecular biology. This program, supported by the Dr. Arnold T. Borer Summer Research Endowment, provides selected students with a stipend, free room and board, and a travel allowance.

- Biochemistry, BS (<https://catalog.sbu.edu/undergraduate/arts-sciences/biology/biochemistry-bs/>)

- Biology Adolescence Education, BS (<https://catalog.sbu.edu/undergraduate/arts-sciences/biology/biology-aded-bs/>)
- Biology, BS (<https://catalog.sbu.edu/undergraduate/arts-sciences/biology/biology-bs/>)
- Biology, Minor (<https://catalog.sbu.edu/undergraduate/arts-sciences/biology/biology-minor/>)

Biology (BIO)

BIO-ELEC BIOLOGY ELECTIVE (3 Credits)

BIO-100A SUCCESS STRATEGIES FOR BIOLOGY (1 Credit)

This course introduces and implements skills to prepare students for success in biology coursework. Instructor permission only.

Corequisite(s): TAKE BIO-101 OR BIO-105

BIO-101 FUNDAMENTALS OF BIOLOGY (4 Credits)

A human-oriented introductory course for non-science majors. Emphasis will be placed on the biological role of cell organization and function integration of systems, inheritance of individual traits and the genetic basis of evolution. The laboratory will introduce a variety of investigational techniques used to study related problems at the cellular and organismal levels.

Corequisite(s): Take BIOL-101

BIO-105 BIOLOGICAL SCIENCE I (4 Credits)

The first half of a two-semester foundation course in biological science for science majors. The course includes a detailed examination of the cellular and molecular basis of life as well as introductions to modern molecular genetics, evolutionary theory, and the history of life on earth. The laboratory component of the course involves a practical examination of the above topics with special emphasis on the scientific method as applied to biology and the writing of detailed laboratory reports.

Corequisite(s): Take BIOL-105

BIO-106 BIOLOGICAL SCIENCE II (4 Credits)

The second half of a two-semester foundation course in biological science for science majors. The major emphases of this semester are animal biology, plant biology, and ecology. The form and function of animals and plants are examined on the molecular, cellular, organismal, and ecological levels. The laboratory component of the course involves a practical examination of the above topics with special emphasis on the scientific method as applied to biology and the writing of detailed laboratory reports.

Prerequisite(s): Take BIO-105

Corequisite(s): TAKE BIOL-106

BIO-110 PLANTS AND HUMAN CULTURE (4 Credits)

From foods, to medicines, to fibers, to building materials, plants serve a vital role in our lives. This course emphasizes how basic plant structure and function interfaces with human existence. Special attention is given to multi-cultural approaches to the use of plant material. Laboratory exercises are designed to highlight practical applications of botany. This course cannot be used to fulfill elective credit requirements for the biology major. NOTE: This course cannot be used for Biology major credit.

Corequisite(s): BIOL-110

BIO-112 HUMAN ECOLOGY (3 Credits)

This course is designed for the liberal arts student who is interested in the relationship between humans and their natural environment. The integrative concept of humans as one species in a global ecosystem will be emphasized. Elementary ecological principles will be applied to such environmental problems as energy resources, land use, air and water pollution, and species extinction. We will seek solutions along multi-disciplinary lines, including economics, political science, and environmental ethics.

Restrictions: RGM.108

BIO-135 INTRODUCTION TO BIOTECHNOLOGY (3 Credits)

This course communicates the importance of scientific practices and their multifaceted application in daily life. The lecture focuses on a current topic in biotechnology that relates to human life and that has caused social concerns. Students survey historical and current evidence to learn about the philosophy of science, the nature of the problem, the causes of concern, and the scientific findings. Students then use the knowledge and skills learned in the course to construct a scientific investigation.

Corequisite(s): BIOL-135

BIO-190 INTRODUCTORY SPECIAL TOPICS IN BIOLOGY (3-4 Credits)

BIO 190 courses will not count towards the Biology major. They may sometimes count towards general education requirements, but not in all cases. Thus, course requirements won't align with Biology program goals, and how they may align with the goals of the university's core curriculum would depend on the topic of a particular offering.

Prerequisite(s): BIO-399

Corequisite(s): TAKE BIOL-190

BIO-211 HUMAN ANATOMY & PHYSIOLOGY (4 Credits)

A study of the structure and function of the human body. Special emphasis is placed upon correlating structure with function in an examination of the human body from the cell and cellular metabolism level to the complex systems level. The laboratory is correlated with lectures and includes exercises of cell and tissue structure and function and exercises covering and integrating the microscopic and gross anatomy of the integument, body membranes, skeleton, articulations, and muscles with their corresponding body functions.

Prerequisite(s): Take BIO-101 or BIO-105

Corequisite(s): Take BIOL-211

BIO-212 HUMAN ANATOMY & PHYSIOLOGY (4 Credits)

A continuation of BIO-211 in which attention is given to the structure and function of biological integrating and control mechanisms and mechanisms for processing, transporting, secreting, and eliminating. Emphasis is given to body maintenance response to external and internal stress. Laboratory exercises cover nervous, endocrine, digestive, circulatory, respiratory and urinary structures and processes in maintaining homeostasis.

Prerequisite(s): Take BIO-211

Corequisite(s): TAKE BIOL-212

Restrictions: RGM.113

BIO-291 GENETICS (3 Credits)

A critical study of biological variation based on the molecular characteristics of genetic information. The course will cover the mechanisms of transmission genetics, the structural nature of nucleic acids, gene expression and its regulation and the role of mutational events in promoting evolutionary change.

Prerequisite(s): Take BIO-105 BIO-106

BIO-292 CELL BIOLOGY (3 Credits)

Cell Biology is a required course taken by Biology majors in their sophomore year. Having completed the introductory General Biology I and II freshmen sequences, students in BIO 292 adopt a microscopic lens and focus intensely on the features and functions of prokaryotic and eukaryotic organisms. Subjects covered in this course include cell evolution; cell reproduction; cell structure and compartmentalization; differentiation; protein synthesis, targeting, and transport; intra- and intercellular signaling mechanisms; and tools and technologies available for studying cells. These techniques include microscopy (bright field, confocal, and SEM), cell fractionation, radiolabeled nucleotides, and fluorescently tagged proteins).

Prerequisite(s): Take BIO-106

BIO-310 PLANT BIOLOGY (3 Credits)

An introduction to the anatomy, physiology, reproduction, ecology, and evolution of plants. This course is designed to heighten your appreciation for and increase your knowledge of the diversity and complexity of the plant kingdom. The greatest emphasis will be placed on the flowering plants and plants of local significance.

Prerequisite(s): Take BIO-105 and BIO-106

Corequisite(s): Take BIOL-310

BIO-318 RESEARCH PARTICIPATION I (1 Credit)

A carefully supervised semester, or year, of organized and formal research on a specific problem to be determined by the student and the faculty advisor. Students will be admitted on a selective basis. A GPA of 2.7 in biology is required as well as permission of a faculty research advisor prior to registration. For successful completion, a research report which follows scientific protocol must be submitted and approved.

Prerequisite(s): Take BIO-105 BIO-106

Restrictions: RGM.104

BIO-319 RESEARCH PARTICIPATION II (1 Credit)

A carefully supervised semester, or year, of organized and formal research on a specific problem to be determined by the student and the faculty advisor. Students will be admitted on a selective basis. A GPA of 2.7 in biology is required as well as permission of a faculty research advisor prior to registration. For successful completion, a research report which follows scientific protocol must be submitted and approved.

Prerequisite(s): Take BIO-105 BIO-106

Restrictions: RGM.104

BIO-321 GEN. MICROBIOLOGY (4 Credits)

This course focuses on bacterial diversity, structure, metabolism, growth and growth control, development of resistance, biofilms, genetics, genomic evolution, and population heterogeneity. Viral diversity, growth, and modes of replication are also investigated. Microbial interactions (microbiomes and host-pathogen interactions) are explored. The lab component reinforces lecture topics and employs both biochemical and genetic organism identification.

Prerequisite(s): Take BIO-291 or BIO-105/BIO-106 with instructor permission only

Corequisite(s): Take BIOL-321

BIO-331 PHYSIOL & ANAT OF HUMAN I (4 Credits)

The first of a two-course sequence that studies the physiology and anatomy of the human body. The chemical and cellular bases for these sciences will be studied. The structure and correlated function of the integumentary, skeletal, muscular, digestive, endocrine and reproductive systems will be examined. The biological controls that result in the integration of these systems will be discussed. The laboratory will consist of the observation of organ system structures on the microscopic and gross anatomy levels. It will also use measurement techniques to quantitatively study physiological processes.

Prerequisite(s): TAKE BIO-105, BIO-106, & BIO-292 or CHEM-301

Corequisite(s): Take BIOL-331

BIO-332 PHYSIOL & ANAT OF HUMAN II (4 Credits)

This course is the second in a two-course sequence concerning the physiology and anatomy of the human body, and covers the structures and functions of the nervous, circulatory, respiratory, and excretory systems, and also the regulation of organismal metabolism and energy balance.

Prerequisite(s): TAKE BIO-331

Corequisite(s): Take BIOL-332

BIO-341 ECOLOGY (3 Credits)

An evaluation of the fundamental interrelations between organism(s) and environment. Field trips will be used to illustrate these phenomena.

Prerequisite(s): Take BIO-105 BIO-106

Corequisite(s): Take BIOL-341

BIO-350 NEUROBIOLOGY (3 Credits)

An investigation of how electrochemical events in the brain enable humans and other animals to respond to environmental stimuli. We start with a detailed study of the properties of individual brain cells and the neurochemical and biophysical factors that modulate their activity. This is then applied to a discussion of (1) the processing of sensory input and motor output; (2) modulation of neural activity associated with moods, psychoactive substances, and states of consciousness; and (3) the mechanisms underlying learning, memory, development of the brain, and conscious experience. In the laboratory, we perform experiments using computer simulations of neuronal physiology and discuss recent developments in neurobiology in a case-study format.

Prerequisite(s): Take BIO-105 BIO-106

Corequisite(s): TAKE BIOL-350

BIO-362 ANIMAL DEVELOPMENT (3 Credits)

This course provides a detailed study of molecular and cellular control of embryonic and post-embryonic development in several model systems (*Drosophila*, *C. elegans*, *Xenopus*, Chicken, and Mouse). Topics include fertilization, gastrulation, organogenesis, pattern formulation, cell differentiation, and molecular signaling mechanisms in development. Evolutionary aspects of developmental biology and current research in the field will be addressed throughout the course.

Prerequisite(s): Take BIO-291 or BIO-292, or BIO-105/BIO-106 with instructor permission only

Corequisite(s): Take BIOL-362

BIO-371 BIOCHEMISTRY (4 Credits)

A study of the structures and functions of biomolecules, bioenergetics, major catabolic and anabolic pathways, and the fundamentals of molecular genetics. The laboratory familiarizes the student with biochemical phenomena and provides experience with important techniques used in biochemistry.

Prerequisite(s): TAKE BIO-291, OR BIO-105 AND BIO-106 with instructor permission only. TAKE CHEM-302 CHML-302.

Corequisite(s): Take BIOL-371

BIO-390 EVOLUTION (3 Credits)

A detailed study of the fundamental principles of biological evolution, including natural selection; neutral theory; population-level evolutionary changes; molecular mechanisms of evolution; the role of morphological, behavioral, and molecular data in our understanding of evolutionary change; and methods of evolutionary research. The course will integrate classical conclusions with contemporary interpretations of evolutionary data, with emphasis placed on modern molecular-based methodologies.

Prerequisite(s): Take BIO-291

BIO-399 BIOLOGY SEMINAR (1 Credit)

The seminar is intended for junior biology majors. Students will read and discuss in a seminar format a series of research papers from the biological literature, organized around a central theme. The themes will vary from semester to semester. Each student will be responsible for analyzing and presenting at least one paper during the course, along with weekly participation in group discussions.

Prerequisite(s): Take BIO-292 or BIO-105/BIO-106 with instructor permission only

BIO-406 PLANT DEVELOPMENT & PHYSIOLOGY (3 Credits)

Growth, development and differentiation of plants are under the control of several interacting factors including chemical, physical and genetic ones. Various aspects of chemical, nutritional and environmental effects on plants will be emphasized. The laboratory will emphasize the experimental methods used to study the various phenomena.

Prerequisite(s): Take BIO-291, BIO-292, or BIO-105/BIO-106 with instructor permission only

Corequisite(s): Take BIOL-406

BIO-418 RES. PARTICIPATION III (2 Credits)

A carefully supervised semester, or year, of organized and formal research on a specific problem to be determined by the student and the faculty director. Students will be admitted on a selective basis. A GPA of 2.7 in biology is required as well as permission of a faculty research advisor prior to registration. For successful completion a report which follows scientific protocol must be submitted and accepted by two faculty members.

Prerequisite(s): Take BIO-105 BIO-106

Restrictions: RGM.104

BIO-419 RES. PARTICIPATION IV (2 Credits)

A carefully supervised semester, or year, of organized and formal research on a specific problem to be determined by the student and the faculty director. Students will be admitted on a selective basis. A GPA of 2.7 in biology is required as well as permission of a faculty research advisor prior to registration. For successful completion a report which follows scientific protocol must be submitted and accepted by two faculty members.

Prerequisite(s): TAKE BIO-105 BIO-106

BIO-456 SENIOR FACULTY COLLOQUIUM (0 Credits)

The colloquium is a series of meetings providing a more informal student-faculty interaction and exchange of ideas on biologically related subjects not normally covered in courses or that may have social, moral or philosophical implications beyond those routinely covered in the curriculum. This two-semester sequence is required of all seniors and is designed to satisfy the Comprehensive Examination requirement for biology majors.

Prerequisite(s): TAKE BIO-399

BIO-456A SENIOR FACULTY COLLOQUIUM (1 Credit)

The colloquium is a series of meetings providing a more informal student-faculty interaction and exchange of ideas on biologically related subjects not normally covered in courses or that may have social, moral or philosophical implications beyond those routinely covered in the curriculum. This two-semester sequence is required of all seniors and is designed to satisfy the Comprehensive Examination requirement for biology majors.

Prerequisite(s): TAKE BIO-399

BIO-457 SENIOR FACULTY COLLOQUIUM (0 Credits)

The colloquium is a series of meetings providing a more informal student-faculty interaction and exchange of ideas on biologically related subjects not normally covered in courses or that may have social, moral or philosophical implications beyond those routinely covered in the curriculum. This two-semester sequence is required of all seniors and is designed to satisfy the Comprehensive Examination requirement for biology majors.

Prerequisite(s): Take BIO-399

BIO-457A SENIOR FACULTY COLLOQUIUM (1 Credit)

The colloquium is a series of meetings providing a more informal student-faculty interaction and exchange of ideas on biologically related subjects not normally covered in courses or that may have social, moral or philosophical implications beyond those routinely covered in the curriculum. This two-semester sequence is required of all seniors and is designed to satisfy the Comprehensive Examination requirement for biology majors.

Prerequisite(s): Take BIO-399

BIO-460 BIOCHEMISTRY SEMINAR (1 Credit)

This course will survey classic and current research papers in the areas of Cell and Molecular Biology. This course fulfills the Comprehensive Examination requirement for students in the Biochemistry Program.

Prerequisite(s): Take BIO-466

BIO-466 MOLECULAR BIOLOGY (4 Credits)

This course examines eukaryotic cells from the perspective of organelle ultrastructure and function, and the regulation of cell function through the differential expression of genes. Lecture topics include cell cycle, chromosome structure, mechanisms of gene regulation, the molecular biology of cancer and recombinant DNA technology. The lab component reinforces the lecture by emphasizing the experimental approaches to the study of cell structure and function.

Prerequisite(s): Take BIO-371

Corequisite(s): Take BIOL-466

BIO-472 IMMUNOLOGY (3 Credits)

This course examines the molecular and cellular basis of humoral and cellular immunity. Antibody structure and function, the origin of antibody diversity and the nature of cellular immunity are examined. Other topics include the role of the major histocompatibility complex in immunity, regulation of the immune system, manifestations of defective regulation (autoimmunity and hypersensitivities) and immunity to infectious agents.

Prerequisite(s): Take BIO-292 or BIO-105/BIO-106 with instructor permission only

Corequisite(s): Take BIOL-472

BIO-490C SP TOP: EXPLORATION OF INFECTIOUS DISEASE (3 Credits)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

BIO-490CH SP TOP: EXPLORATION OF INFECTIOUS Disease Honors (3 Credits)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

Restrictions: RG.HON

BIO-490D SP TOP: MICROBIOLOGY FOR NURSING DISEASE (3 Credits)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

BIO-490E SP TOP: MICROBIOLOGY FOR NURSING LAB DISEASE (1 Credit)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

BIO-490F SP TP: BIOCHEMISTRY OF THE CENTRAL DOGMA (3 Credits)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

BIO-490G SP TOP: PARASITOLOGY (3 Credits)

The title and nature of this course will vary from semester-to-semester. The course will serve as an upper-level elective that focuses on a specific topic of Biology that is of special interest to a member of the department. The special topic and instructor will be announced prior to registration for the semester in which it is offered.

BIO-494 GENOMICS (3 Credits)

An introduction to the fields of genomics, functional genomics, and proteomics. The course begins with a description of methods used for sequencing and analyzing genomes. We then explore what is known about the structure and functional organization of the genomes of prokaryotic and eukaryotic organisms. The course concludes with a discussion of the various approaches being used to determine the functions of individual genes, and how gene expression is regulated. In the laboratory, students use online databases and computational tools to explore and analyze genome sequences.

Prerequisite(s): Take BIO-291

Corequisite(s): Take BIOL-494

Biology Lab (BIOL)

BIOL-101 FUNDAMENTALS OF BIOLOGY LAB (0 Credits)

Lab occurs once a week and goes along with BIO 101.

Corequisite(s): BIO-101

BIOL-105 BIOLOGICAL SCI. I LAB (0 Credits)

Lab occurs once a week and is taken with BIO 105.

Corequisite(s): Take BIO-105

BIOL-106 BIOLOGICAL SCI. II LAB (0 Credits)

Lab occurs once a week and is taken with BIO 106.

Corequisite(s): Take BIO-106

BIOL-110 PLANTS AND HUMAN CULTURE LAB (0 Credits)

Corequisite(s): BIO-110

BIOL-135 INTRODUCTION TO BIOTECHNOLOGY LAB (1 Credit)

This laboratory course provides a user-friendly environment to introduce basic biotechnology techniques and practices to help students understand how to address biotechnology-related social concerns. Laboratory exercises include different laboratory practices in the field of biotechnology, ways to analyze and interpret experimental data, and the how to arrive at conclusions based on evidence.

Corequisite(s): BIO-135

BIOL-190 INTRODUCTORY SPECIAL TOPICS IN BIOLOGY LAB (0 Credits)

BIO 190 courses will not count towards the Biology major. They may sometimes count towards general education requirements, but not in all cases. Thus, course requirements won't align with Biology program goals, and how they may align with the goals of the university's core curriculum would depend on the topic of a particular offering.

Prerequisite(s): BIO-399

Corequisite(s): TAKE BIO-190

BIOL-211 HUMAN ANAT & PHYSIOL LAB (0 Credits)

Lab occurs once a week and is taken with BIO 211.

Corequisite(s): Take BIO-211

BIOL-212 Human Anat & Physiol Lab (0 Credits)

Lab occurs once a week and is taken with BIO 212.

Corequisite(s): Take BIO-212

Restrictions: RGM.113

BIOL-293 GENETICS/CELL BIO LABORATORY (1 Credit)

This course uses laboratory experiments to provide students experiential learning opportunities for many of the topics covered in Genetics (BIO-291) and Cell Biology (BIO 292). These topics include transmission genetics, genetic and cellular pathways, recombinant DNA technology, chromosome structure, and cellular function.

Corequisite(s): Take BIO-291 or BIO-292. Take BIO-105 and BIO-106

BIOL-310 PLANT BIOLOGY LAB (0 Credits)

Lab occurs once a week and is taken with BIO 310.

Corequisite(s): Take BIO-310

BIOL-321 Gen Microbiology Lab (0 Credits)

Lab occurs once a week and is taken with BIO 321.

Corequisite(s): Take BIO-321

BIOL-331 PHYSIOL & ANAT HUMAN I LAB (0 Credits)

Lab occurs once a week and is taken with BIO 331.

Corequisite(s): Take BIO-331

BIOL-332 PHYSIO/ANAT OF HUMAN LAB II (0 Credits)

Lab occurs once a week and is taken with BIO 332.

Corequisite(s): TAKE BIO-332

BIOL-341 ECOLOGY LAB (0 Credits)

Lab occurs once per week and is taken with BIO 341.

Corequisite(s): Take BIO-341

BIOL-350 NEUROBIOLOGY LAB (0 Credits)

Lab occurs once per week and is taken with BIO-350.

Corequisite(s): Take BIO-350

BIOL-362 Dev Biology Lab (0 Credits)

Corequisite(s): Take BIO-362

BIOL-371 BIOCHEMISTRY LAB (0 Credits)

The laboratory familiarizes the student with biochemical phenomena and provides experience with important techniques used in biochemistry.

Corequisite(s): Take BIO-371

BIOL-406 PLANT DEVELOPMENT & PHYSIOLOGY LAB (0 Credits)

Lab occurs once per week and is taken with BIO 406.

Corequisite(s): TAKE BIO-406

BIOL-466 MOLECULAR BIOLOGY LAB (0 Credits)

Lab occurs once per week and is taken with BIO 466.

Corequisite(s): Take BIO-466

BIOL-472 IMMUNOLOGY LAB (0 Credits)

Lab occurs once per week and is taken with BIO 472.

Corequisite(s): TAKE BIO-472

BIOL-490 SPECIAL TOPICS IN BIOLOGY LAB (1 Credit)

BIOL-490C SP TOP LAB: EXPLORATION OF INFECTIOUS DISEASE LAB (1 Credit)

BIOL-490CH SP TOP LAB: EXPLORATION OF INFECTIOUS DISEASE LAB HONORS (1 Credit)

Restrictions: RG.HON

BIOL-494 GENOMICS LAB (0 Credits)

Corequisite(s): Take BIO-494