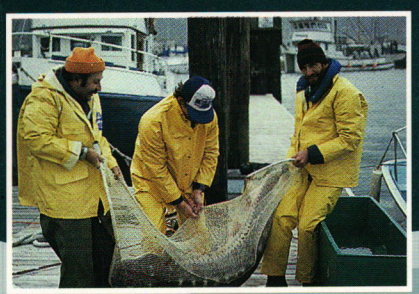
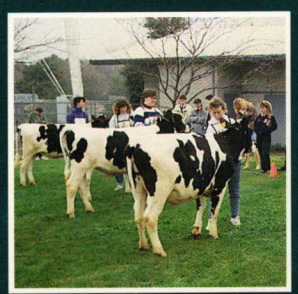
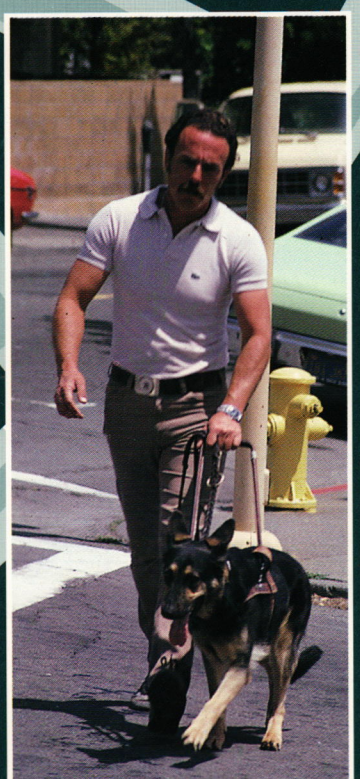
HIGHLIGHTS

Department of Animal Science

University of California, Davis







HIGHLIGHTS

A sampling of current teaching, research,

and extension activities of the

Department of Animal Science

University of California, Davis

Project Coordinators: G. E. Bradford, F. S. Conte, and E. O. Price.

Appreciation is extended to the faculty, staff, and students
who contributed to this Department effort.

Special thanks are extended to Steven Culver, project staff coordinator;
Eileen O'Farrell, editing and layout design; and
Robin Thomas, secretarial and text graphics support.

MCMXCIII

TABLE OF CONTENTS

Highlights provides information about our Animal Science Department and its programs. Each faculty member has included a synopsis of a current project, although by no means is this a complete summary of all our research or extension activities. We hope you find the publication interesting and welcome your comments and suggestions.

INTRODUCTION
Dr. G. Eric Bradford

The Department of Animal Science, originally the Division of Animal Husbandry, had its beginning in Berkeley in 1901. The Division was moved to Davis in 1908 and 1909 and later became the Department of Animal Husbandry. The Department's name was changed to Animal Science in 1967, recognizing its emphasis on the basic biology of domestic animals as well as animal husbandry in its teaching and research programs.

The Animal Science Department at UC Davis is the only such department in the UC system. We engage in teaching, research, and extension related to the biology and production of domestic animals. Our primary focus is on animals used to produce food and fiber, including freshwater and marine species. We also have programs emphasizing horses and, more recently, other companion animals, especially dogs and cats. We use laboratory animals (rabbits, hamsters, rats, and mice) for pilot research projects because of their lower costs and shorter generation intervals compared to larger species.

The Animal Science Department at UC Davis is the only such department in the UC system. We engage in teaching, research, and extension related to the biology and production of domestic animals.

Undergraduate and graduate teaching are very important to us. We currently have 368 students in our two undergraduate majors, Animal Science and Agricultural Science and Management. When they graduate, our students go into positions in the livestock industry, teaching, extension, and biomedical research. Many go on to graduate and professional schools. We also have 41 graduate students in our two Master's programs—the M.S. in Animal Science and the Masters of Agriculture and Management (cooperative with the UC Davis School of Management)—and our faculty are sponsoring 54 additional M.S. and Ph.D. students enrolled in 11 different Graduate Group Programs.

Disciplines represented among our 27 teaching and research faculty include behavior, ecology, genetics, microbiology, nutrition, and physiology. Some of our scientists may use modern molecular biology techniques, but our overall mission focuses on whole animal biology and problems related to animal production.

The department generally has 45 to 50 individual ongoing research projects resulting in 75 to 90 publications per year. We are also involved in several areas of cooperative research with colleagues in other departments, including Agronomy and Range Science, Animal Physiology, Avian Sciences, Biochemistry, and Food Science and Technology, and in the School of Veterinary Medicine (Physiological Sciences, Reproduction, and Equine Research Laboratory) as well as the School of Medicine.

There are six Cooperative Extension Specialists in the Department who work with livestock and aquatic animals, including a new position in waste management. Some 37 livestock and dairy farm advisors in county Cooperative Extension offices are key members of UC's team in the animal sciences.

TEACHING, RESEARCH, AND EXTENSION FACULTY

T.E. Adams - Associate Professor
Graduate Groups: Endocrinology, Physiology
Research Interests: Biochemical endocrinology; hormone receptor dynamics; endocrine control of reproduction.

G.B. Anderson - Professor
Graduate Groups: Cell and Developmental Biology, Physiology
Research Interests: Reproduction; embryo development; *in vitro* embryo culture, manipulation and transfer; gene transfer.

R.L. Baldwin - Sesnon Professor of Animal Science
Graduate Groups: Endocrinology, Nutrition, Physiology
Research Interests: Energy metabolism; systems analysis; lactation.

D.L. Bath - Extension Specialist: Dairy Nutrition
Research Interests: Dairy nutrition; DHIA liasion; computerized ration formulation; forage quality; byproduct feeds; herd management.

P.J. Berger - Associate Professor
Graduate Group: Physiology
Research Interests: Reproduction; fertilization; gamete and embryo physiology and nuclear transfer; fertility.

K. Beer - Lecturer
Specialty: Aquaculture

S.L. Berry - Extension Specialist: Dairy Management and Health
Research Interests: Dairy management and health; records analysis; interrelationships of disease, management, and economics.

D.L. Brown - Associate Professor
Graduate Groups: International Agricultural Development, Nutrition
Research Interests: Control of body nutrient reserves; nutritional ecology; nutritional toxicology

C.C. Calvert - Associate Professor
Graduate Groups: Avian Sciences, Endocrinology, Nutrition
Research Interests: Protein metabolism; energy metabolism; homeorhesis; systems analysis.

E.S. Chang - Professor (Bodega Marine Lab)
Graduate Groups: Ecology, Endocrinology
Research Interests: Endocrinology; comparative biochemistry and larval development of aquatic invertebrates

W.H. Clark - Professor (Bodega Marine Lab)
Graduate Groups: Cell and Developmental Biology, Ecology, Zoology
Research Interests: The reproduction of marine invertebrates.

D.E. Conklin - Associate Aquaculturist
Graduate Groups: Ecology, Nutrition
Research Interests: Nutrition of aquatic invertebrates and fish.

F.S. Conte - Extension Specialist: Aquaculture; Lecturer
Extension program: Fresh water and marine aquaculture production and related government issues.
Research interests: Finfish nutrition, oyster larval behavior and growout, finfish nutrition.

E.J. DePeters - Associate Professor
Graduate Group: Nutrition
Research Interests: Ruminant nutrition in dairy cattle; factors affecting milk nitrogen and fat; intake and digestive function; forage utilization.

S.I. Doroshov - Professor
Graduate Groups: Ecology, International Agricultural Development
Research Interests: Developmental biology; hatchery technology of cultured fish; environmental physiology of early life stages.

J.R. Dunbar - Extension Specialist: Livestock Nutrition
Extension Programs: Computerized nutrition programs.
Research Interests: Beef nutrition and management

J.G. Fadel - Associate Professor
Graduate Groups: International Agricultural Development, Nutrition
Research Interests: Quantitative applications; feed and fiber evaluations; management.

T.R. Famula - Associate Professor
Graduate Group: Genetics
Research Interests: Quantitative genetic theory; genetic control of animal growth.

G.A.E. Gall - Professor
Graduate Groups: Ecology, Genetics, International Agricultural Development
Research Interests: Fish breeding; quantitative genetics and selection; salmon population genetics; conservation biology.

I. Garnett - Senior Lecturer and Director, M.A.M. Program
Preparation of professionals for high-level management in the animal industries.

D. Hedgecock - Geneticist (Bodega Marine Lab)
Graduate Groups: Genetics
Research Interests: Genetics of aquatic animals.

S.S.O. Hung - Associate Professor
Graduate Groups: Ecology, International Agricultural Development, Nutrition
Research Interests: Fish feeding nutrition and biochemistry.

Y.B. Lee - Professor
Graduate Groups: Agricultural Chemistry, Food Science, Physiology
Research Interests: Meat science and muscle biology; growth and development of muscle and adipose tissue; postmortem muscle biochemistry; meat quality.

J.M. Macy - Professor
Graduate Groups: Microbiology
Research Interests: Metabolism and physiology of anaerobic microorganisms in rumen and sediments; anaerobic selenium detoxification; reductive dechlorination of chlorinated aromatics; isolation and study of new anaerobes.

J.F. Medrano - Associate Professor
Graduate Groups: Genetics, International Agricultural Development
Research Interests: Physiological/molecular animal genetics; milk proteins; animal growth.

G.P. Moberg - Professor
Graduate Groups: Animal Behavior, Endocrinology, Physiology
Research Interests: Endocrine regulation of reproduction of mammals and fish; biology of stress; aquaculture.

D. Morse - Assistant Extension Specialist: Waste Management
Research Interests: Animal waste management

J.D. Murray - Associate Professor
Graduate Group: Genetics
Research Interests: Use of transgenic animals to study gene expression during differentiation; molecular genetics; cytogenetics.

A.M. Oberbauer - Assistant Professor
Graduate Groups: Genetics, Physiology
Research Interests: Cell and molecular growth, biology and development.

J.W. Oltjen - Associate Extension Specialist: Animal Management Systems
Extension Program: Computer Decision Support Software; beef quality assurance; standardized performance analysis for cattle and sheep ranches.
Graduate Groups: Nutrition
Research Interests: Animal management systems; resource use in animal agriculture; beef cattle growth.

E.O. Price - Professor, Chair
Graduate Group: Animal Behavior
Research Interests: Early experience effects on livestock behavior; reproductive behavior; effects of domestication on behavior.

J.F. Roser - Associate Professor
Graduate Groups: Endocrinology, Physiology
Research Interests: Equine reproductive physiology and endocrinology.

R.D. Sainz - Assistant Professor
Graduate Groups: International Agricultural Development, Nutrition
Research Interests: Beef cattle nutrition; ruminant nutrition

D. Van Liew - Lecturer, Coach, Livestock Judging Team
Specialty: Livestock Judging

R.A. Zinn - Associate Professor (Desert Research and Extension Center)
Research Interests: Ruminant nutrition; feedlot cattle nutrition and management; factors associated with digestive function.

ACTIVE EMERITI

R. Albaugh - Farm advisor, Monterey Co., 1927-1949; Specialist, UCD, 1949-1966; Active emeritus, 1966-present.
Program Areas: Beef cattle management, crossbreeding; horses.
Current interests: Cooperative Extension history, horses, composite breeding of beef cattle.

G.E. Bradford - Chair, Animal Science Dept., 1973-1978, 1990-1992.
Research Interests: Genetics of growth and reproduction; sheep breeding; major genes; international agriculture.
Current Activities: Small Ruminant CRSP; Director, Animal Agriculture Research Center.

P.T. Cupps - Professor
Research Interests: Reproduction of livestock species; semen quality; embryo transfer.
Recent work: Edited 2nd Ed., *Reproduction in Domestic Animals.*

W.N. Garrett - Chair, Animal Science Dept., 1987-1990; President ASAS, 1983-1984.
Research Interests: Ruminant nutrition; net energy system of feed evaluation; animal energetics; body composition.

H. Heitman, Jr. - Graduate Advisor
Research Interests: Swine nutrition; environmental physiology

R.C. Laben - Master Advisor, 1975-1984.
Research Interests: Dairy cattle breeding, genetic and management aspects of mastitis control.
Current activities: Alumni relations, annual Dairy Cattle Day.

J.H. Meyer - Chair, Animal Science, 1960-1963; Dean, College of Agricultural and Environmental Science, 1963-1969; Chancellor, UCD, 1969-1987.
Research Interests: Ruminant nutrition and animal energetics.
Current activities: Chair, Animal Science Development Committee and CAES Research Policy Committee; research on agricultural graduate placement, future directions of Land Grant universities.

W.C. Weir - Dean of Students, UCD, 1957-1962; Chief-of-Party, UC—Univ. of Chile Convenio, 1969-1971; Chair, Nutrition Dept., 1973-1981; Associate Director, Small Ruminant Program, 1981-1986; Director, Humphrey Fellows Program, 1986-1990.
Research Interests: Range livestock nutrition.
Current Activities: Chair, Animal Science Memorial Fund Committee.

OTHER EMERITI

F.D. Carroll - Professor

F.D. Murrill, Extension Dairy Specialist

C.L. Pelissier - Extension Dairy Scientist

W.C. Rollins - Professor

H.T. Strong - Extension Livestock Specialist

TEACHING AND RESEARCH FACILITIES

The Department of Animal Science moved into the newly constructed Meyer Hall in 1987. Along with offices, Meyer Hall provides almost 20,000 sq.ft. of laboratory space. The Department also maintains animal research and teaching facilities on campus occupying about 60 acres, and actively farms (pasture, hay crops, and feed grains) about 475 acres. The Department also has research programs at four University field stations.

BEEF CATTLE. A small Hereford breeding herd is kept on campus, with a fall calving season. Research projects include work on endocrinology, nutrition, and immunology. The Department also maintains a commercial herd of about 200 animals at the UC Sierra Foothill Research and Extension Center near Marysville. Research on cattle feeding is carried out at the UC Desert Research and Extension Center near El Centro in the Imperial Valley.

The campus feedlot can house up to 500 cattle in both group and individual pens. The Department's feedmill at the feedlot can process a wide variety of feed ingredients and produce both commercial and research rations.

DAIRY CATTLE. The dairy houses about 200 head of cattle, mostly Holstein. About 120 cows are milked twice daily in a new computerized parlor. The herd average is approximately 19,700 pounds of milk, sold to Crystal Cream & Butter Company of Sacramento. The herd is used for research in nutrition, genetics, reproduction, and animal health as well as teaching.

HORSES. The Animal Science horse facility houses approximately 40 mares and 12 stallions that are used for breeding, research, and teaching. Research focuses on the hormonal mechanisms that regulate fertility in the mare and stallion.

SWINE. The swine facility houses approximately 300 pigs, including 20 boars and 50 breeding sows. Pigs are used for teaching and research. Current research includes projects on fertility, embryo transfer, gene manipulation, behavior, nutrition, and immunology.

SHEEP. Some 400 sheep are maintained on campus, including small purebred flocks of Suffolk, Finnsheep, and Rambouillet. The main flock of prolific crossbred sheep is on an accelerated lambing schedule. Research includes projects on nutrition, reproduction, genetics, embryo transfer, and endocrinology. Faculty are also involved in research in sheep breeding, behavior, and nutrition at the UC Hopland Research and Extension Center near Ukiah.

GOATS. The Dairy Goat Research Facility currently houses about 60 goats, predominantly Alpine. The facility, with a modern milking parlor, is maintained free of caprine arthritis encephalitis. Research focuses on nutrition, physiology, genetics, and behavior.

FISH. Researchers in freshwater aquaculture use the facilities of the Aquaculture and Fisheries Program located at two sites on campus. The Aquatic Center has 50 fiberglass and concrete tanks with a total capacity of 150,000 liters and 11 indoor aquatic animal labs ranging from 300 to 800 square feet. These labs have over 500 tanks with capacities from 20 to 1,200 liters. The Putah Creek Facility has 50 outdoor fiberglass tanks totalling 335,000 liters and two indoor aquatic animal labs with 110 tanks.

COLE FACILITY. The Cole facility is a four-building complex designed for research in physiology and metabolism. Two buildings are used for intensive experiments that may be difficult to carry out at another facility. Studies with cattle, sheep, goats, and pigs are common. The Cole facility also has a meats laboratory and a small-animal laboratory that houses colonies of rats, mice, hamsters, and rabbits and has facilities for fish research.

BODEGA MARINE LABORATORY. Located about 60 miles north of San Francisco, Bodega Marine Laboratory consists of two main buildings designed for research and teaching in aquaculture and ecology. The aquaculture building offers extensive facilities for maintaining and rearing fish, crustaceans, mollusks, and other aquatic invertebrates. Three Department of Animal Science faculty are located there.

UNDERGRADUATE TEACHING PROGRAMS

Students studying for the Bachelor of Science degree in Animal Science at UC Davis begin with a strong foundation in mathematics, chemistry, general biology, and one to three introductory courses in animal science and production. Upper division courses focus on the disciplines that make up the animal sciences (behavior, genetics, nutrition, physiology, managerial economics) and on the study of biological functions that require an integration of the basic sciences (*e.g.*, growth, lactation, reproduction). The production, care, and management of animal species is taught in advanced courses based upon this scientific foundation.

Research and production internships, independent studies and management traineeships in laboratories, campus animal facilities, field stations, and private enterprises provide students with first-hand experience in the application of the animal sciences to problem solving in biology, animal agriculture, and health care.

THE UNDERGRADUATE MAJORS
(December 1992 Enrollments)

Agricultural Science and Management - Animal Science Option (21)

This major combines a sound education in Animal Science with training in managerial economics. Graduates are well prepared for enterprise management, professional schools, extension work, sales, and financial institutions. The Plant, Food, and Range Science Options will soon become part of a more general Agricultural Systems and Environment Major, and the Animal Science Option described here has been reorganized as the Animal Science and Management Major effective fall 1993.

Animal Science - Animal Biology Option (337)

This rigorous major educates students in all aspects of domestic animals with an emphasis on organismal animal biology. Graduates are well prepared for medical, veterinary, and graduate school. They may elect production courses and internships needed to prepare them for work in the livestock and companion animal industries.

Animal Science - Aquaculture Option (10)

This option provides an education similar to Animal Biology but with more focus on aquatic animals. It prepares students for both commercial aquacultural enterprise and research careers.

OTHER PROGRAMS

Joint program with the School of Veterinary Medicine

With proper course selection, students interested in food animal medicine may enter the School of Veterinary Medicine after two years in the Animal Science program and receive a B.S. in Animal Science while working on their D.V.M.

Teaching contributions to other campus programs

Animal Science faculty teach courses in behavior, genetics, international agricultural development, management, molecular biology, nutrition, and physiology that are required by or very important to many other majors and programs on campus. Examples are Nutrition 110 (an upper division class in biochemistry-based general nutrition) required by Nutritional Science and Animal Physiology majors and Physiology 121 and 130 (Reproductive Physiology and Endocrinology, respectively), both critical for Animal Physiology majors with interests in organismal biology.

The Animal Science Department is a major contributor to the campus General Education Program and provides a total of three certified GE courses. These courses not only offer breadth and writing experience for social science and humanity students, but also provide our predominantly urban campus community with a better understanding of animal agriculture.

STUDENTS AND CAREERS

Where our students come from:

Most of the student body is drawn from California high school students ranked in the upper 12.5% of their classes and a smaller number of community college transfers. More than 90% of incoming students are from urban or suburban environments and have little or no experience with agricultural animals. More than 75% of recent classes have been female, and an increasing proportion of our students are beginning their degree programs at ages in excess of 25 years.

Where our students have gone:

Forty-two percent of Animal Science alumni are veterinarians, physicians, lawyers, scientists, or university professors. Fifteen percent own or manage non-ranch businesses and another eight percent of alumni own or manage a farm or ranch full time. The rest are scattered among a wide range of careers and professions.

Of freshmen entering as Animal Science majors, 27% graduate as Animal Science majors, 9% as other agriculture majors, 13% in business-related majors, and 10% in other biology majors. Of transfer students, 50% finish as Animal Science majors, 5% in other agriculture, and 5% and 9% in business and biology, respectively.

FUTURE DIRECTIONS

A comprehensive curriculum in Animal Care and Management has been developed by the Animal Science Department to provide an education in biology-based animal production, product processing and marketing, and animal enterprise management. Although primarily aimed at students in the Animal Science and Management major, these courses can be used to fulfill requirements of the Animal Science major and have attracted students from Food Science and Agricultural Economics.

Instruction in companion animal biology has recently been incorporated at the lower division level in both introductory classes and in a separate Companion Animal Biology course. If interest warrants, the Department of Animal Science plans to offer companion animal courses at the upper division level to complement existing equine care and management courses.

GRADUATE PROGRAMS

Faculty in the Department of Animal Science sponsor graduate students enrolled in the Master of Science in Animal Science (M.S.) and Master of Agriculture and Management (M.A.M.) Degree Programs and M.S. and Ph.D. degree programs offered by various Graduate Groups on campus. The M.S. in Animal Science and the M.A.M. Graduate Programs are administered by the Department whereas the Graduate Group Programs are administered by the campus-based Division of Graduate Studies. Approximately 95 graduate students are currently sponsored by Animal Science faculty in these three programs and are housed in the Department of Animal Science. Brief descriptions of these programs are presented below.

MASTER OF SCIENCE IN ANIMAL SCIENCE PROGRAM

The goal of the M.S. in Animal Science Graduate Program is to provide post-graduate academic and technical education to prepare graduates to assume positions of leadership in teaching, research, extension, and animal industries associated with domestic animal biology and production. This is accomplished through formal instruction, independent study, and research and interaction with other graduate students and faculty from on and off the Davis campus.

Students acquire training and experience in one or more areas of specialization such as animal behavior, aquaculture, genetics, nutrition, physiology, or systems analysis. In all areas, students are expected to engage in research on topics relevant to animal biology or production.

The breadth and depth of our faculty in the various animal science disciplines account for the relative strength of the M.S. program. The recent addition of faculty in aquaculture, molecular biology, and animal behavior provides an unusual degree of breadth to this graduate program.

The M.S. in Animal Science degree is a terminal objective for many of our students who seek employment in various facets of the animal industry or as farm advisors. It also provides an opportunity for pre-veterinary students to gain additional experience working with animals, especially domestic livestock. Finally, for some students, the M.S. program serves as a bridge to a Ph.D. degree in one of the basic disciplines in preparation for university teaching or advanced research.

An important strength of the M.S. Program is its diversity and flexibility, which increase the potential for meeting individual student needs. Its interdisciplinary nature is an important attribute that sets it apart from other degree programs.

Thirty-three students are currently enrolled in the M.S. Program.

MASTER OF AGRICULTURE AND MANAGEMENT (M.A.M.)

In 1989 the Department of Animal Science re-established the Master of Agriculture and Management (M.A.M.) Program. Industry indicated the need for graduates versed in the principles and concepts of management yet conversant in the technical aspects of animal agriculture. The goal of the M.A.M. program is to combine training in these two areas while advancing the competence of the student beyond the undergraduate level.

The M.A.M. degree is a professional degree. However, it is not designed specifically to produce a farm or ranch manager. In fact, only a small minority of graduates today will return to traditional production agriculture on the farm. A recent study by Dr. J.H. Meyer indicated that only 8% of the Animal Science alumni who graduated from 1956 to 1987 became ranch owners or managers. The program will still meet the needs of these individuals but is designed to prepare the student for a much broader arena—the animal industries sector of agribusiness. The degree curriculum focuses on management and application as well as development of technical expertise.

The M.A.M. degree program normally requires two years to complete. The student begins by taking courses in the Graduate School of Management's M.B.A. program that focus on business and economics. The objective is to develop financial, problem-solving, decision-making, and communication skills. In the second year the student undertakes additional course work in business and economics and animal science to develop a specific area of interest.

Business or administrative experience, a key element in the program, is accomplished through an internship in the private or public sector. Each student is also required to conduct an independent research project. There are three objectives of this aspect of the program:

- introduce the student to the elements and disciplines of sound research
- develop the student's ability to evaluate data critically and communicate results
- develop further technical competence in a specific area.

The program, now in its third year, has shown steady growth, from a single student in the initial year to a current enrollment of eight students. Students' interests range from aquaculture to the horse industry to beef feedlot management.

Dr. Ian Garnett serves as Director of the M.A.M. Program. He also teaches ANS 143, Pig and Poultry Care and Management; ANS 147, Dairy Processing and Marketing; ANS 148, Enterprise Analysis in Animal Industries; and ANS 200, Strategies in Animal Production.

GRADUATE GROUP PROGRAMS

Many graduate programs at UC Davis are offered through interdisciplinary graduate groups composed of faculty from various departments on campus. Through membership in graduate groups, Animal Science faculty are eligible to serve as major professor and guide thesis research for graduate students seeking advanced degrees in Agricultural Chemistry, Animal Behavior, Avian Sciences, Cell and Developmental Biology, Ecology, Endocrinology, Food Science, Genetics, International Agricultural Development, Microbiology, Nutrition, Physiology, and Zoology. Graduate Group students sponsored by Animal Science faculty are eligible to receive departmental support (fellowships and graduate assistantships) and other privileges (*e.g.*, assignment of a desk in Meyer Hall).

Listed below are the number of Animal Science faculty who hold membership in various Graduate Groups and the number of Group students sponsored by Animal Science faculty for the 1992-93 academic year.

Graduate Group	Number of Faculty	Number of Students
Agricultural Chemistry	1	1
Animal Behavior	2	1
Avian Sciences	1	0
Cell and Developmental Biology	2	2
Ecology	6	6
Endocrinology	6	4
Food Science	1	1
Genetics	6	14
International Agricultural Development	7	1
Microbiology	1	0
Nutrition	8	9
Physiology	8	11
Zoology	1	4
		54

LIST OF COURSES

LOWER DIVISION

ANIMAL SCIENCE (ANS)

1 Domestic Animals & People
2 Introductory Animal Science
15 Introductory Horse Husbandry
18 Introductory Aquaculture
21 Livestock & Dairy Cattle Judging
22A,B Animal Judging
41 Domestic Animal Production
41L Domestic Animal Production Lab
42 Introductory Companion Animal Biology
49A,B,C Animal Management Practices

UPPER DIVISION

AGRICULTURAL SCIENCE & MANAGEMENT (ASM)

150 Applied Statistics in Agricultural Sciences

ANIMAL GENETICS (ANG)

107 Genetics & Animal Breeding
108 Methods in Quantitative Animal Breeding
109 Introduction to Parameter Estimation
111 Molecular Biology Laboratory Techniques

ANIMAL SCIENCE (ANS)

102 Limited Resource Animal Agriculture
104 Principles of Domestic Animal Behavior
105 Behavioral Adaptations of Domestic Animals
106 Domestic Animal Behavior Laboratory
115 Advanced Horse Production
118 Aquatic Animal Production
119 Invertebrate Aquaculture
120 Principles of Meat Science
120L Principles of Meat Science Laboratory
123 Animal Growth
124 Lactation
128 Linear Programming in Animal Agriculture
131 Reproduction & Early Development in Aquatic Animals
135 Experimental Biochemistry Laboratory
140 Management of Laboratory Animals
141 Equine Enterprise Management
143 Pig & Poultry Care & Management
144 Beef Cattle & Sheep Production
145 Meat Processing & Marketing
146 Dairy Cattle Production
147 Dairy Processing & Marketing
148 Enterprise Analysis in Animal Industries

MICROBIOLOGY (MIC)

177 Metabolism of Anaerobic Bacteria
177L Laboratory in Metabolism of Anaerobic Bacteria

NUTRITION (NUT)

110 Principles of Nutrition
115 Animal Feeds & Nutrition
122 Ruminant Nutrition & Digestive Physiology
122L Ruminant Nutrition Laboratory
124 Nutrition & Feeding of Finfish & Shellfish

PHYSIOLOGY (PHS)

121 Physiology of Reproduction
121L Physiology of Reproduction Laboratory
130 Physiology of the Endocrine Glands

VETERINARY MEDICINE (VMD)

170 Ethics of Animal Use

GRADUATE LEVEL

ANIMAL BEHAVIOR (ANB)

220 Behavioral Aspects of Animal Domestication

ANIMAL GENETICS (ANG)

204 Theory of Quantitative Genetics
206 Advanced Domestic Animal Breeding
208 Estimation of Genetic Parameters
211 Genetic Engineering of Animals

ANIMAL SCIENCE (ANS)

200 Strategies in Animal Production
206 Models in Agriculture & Nutrition
215 Advanced Concepts of Growth Regulation
216 Grant Writing Techniques
235 Advanced Techniques in Animal Nutrition Research

ENDOCRINOLOGY (EDO)

240 Biochemical Endocrinology

GENETICS (GGG)

201B Cytogenetics
201D Quantitative & Population Genetics

NUTRITION (NUT)

202 Advanced Nutritional Energetics
254 Applications of Systems Analysis in Nutrition
256 Nutritional & Hormonal Control of Animal Metabolic Function
257 Selected Topics in Nutritional & Hormonal Control of Nitrogen Metabolism

PHYSIOLOGICAL SCIENCES (PHC)

205A Intermediary Metabolism of Animals

PHYSIOLOGY (PHS)

220 General & Comparative Physiology of Reproduction
222 Mammalian Gametogenesis & Fertilization
230 Advanced Endocrinology

(Seminars and variable unit courses are excluded.)

ANIMAL SCIENCE EXTENSION: OVERALL HIGHLIGHTS

Steven L. Berry

Animal Science Extension is comprised of six campus-based specialists, a programmer/ analyst, a staff research associate, and about 30 county-based livestock and dairy farm advisors. The campus-based specialists are responsible for the program areas of livestock nutrition, dairy nutrition, waste management, systems management, aquaculture, and dairy management and health.

Animal Science Extension in California is unusual in many regards. It was the first state to hire a specialist for animal waste management and one of few states that has an aquaculture specialist and a veterinarian as members of the unit. We have developed an international reputation for designing and writing computer programs to help with ration formulation and recordkeeping to aid animal producers with rational, economical, management decisions. Many of the dairy advisors have more cows in their county or area than exist in entire states. Farm advisors all conduct applied research as well as traditional extension educational activities. Many of our farm advisors have developed special interests and, in fact, have taken active statewide roles in areas such as watershed management, public policy and land use, animal welfare, swine production, waste management, mastitis control, worker safety, and quality assurance.

Research and outreach activities of the specialists and advisors are as diverse as the State of California.

Research and outreach activities of the specialists and advisors are as diverse as the State of California. We are in the process of writing and developing a publication on guidelines for manure management on large drylot dairies for use by people involved in public policy decision making. Publications have been completed on guidelines for animal care practices of swine and beef and are nearing completion for dairy and sheep. These publications are also aimed at informing people interested in public policy about animal welfare from a scientific point of view. Specialists and farm advisors have collaborated to develop software for beef cattle, sheep, horses, swine, and dairy cattle that formulate rations on the basis of least cost of maximum income above feed cost. We have also developed recordkeeping programs for beef cattle and swine that allow the user to keep detailed production records on individual animals and also to analyze those records to determine weak spots in the management chain. These programs have been sold to producers and educational institutions nationally and internationally. The State of Nebraska has purchased copies of the ration software to be used by their faculty and extension personnel. We will also be developing some programs to disseminate current information on aquaculture. Some other programs involving farm advisors and specialists include water use in producing meat from beef and sheep; personnel safety and management; public policy and land use; watershed management; food safety, quality assurance and residue avoidance; and holistic resource management.

We plan to continue to emphasize software development. Our programs are carefully designed, user friendly, extensively beta-tested, and supported by our Department. We were the first unit in the University of California to develop and market commercial quality software for agricultural producers. We plan to work on developing models to help producers analyze various management scenarios in terms of probable economic outcomes and risk. We are developing collaborative relationships with other departments, colleges, and public agencies.

IMMUNOCASTRATION: AN EFFECTIVE ALTERNATIVE TO PHYSICAL CASTRATION IN MANAGEMENT OF BEEF CATTLE AND SHEEP

Tom Adams, Cindy Daley, Betty Adams, and Hirofumi Sakurai

Physical castration is a common and well established management practice in livestock production that improves behavioral and carcass traits of wethers and steers. However, the stress and unalleviated pain perceived to be associated with castration has drawn the focus of a small but vocal segment of the non-farm community. In addition, castrated animals grow less rapidly than testes-intact contemporaries, probably due to the absence of the testicular hormones (primarily testosterone), which have a general anabolic (growth promoting) effect. Anabolic hormone-containing implants or feed additives (*i.e.*, Ralgro, Synovex, Zeranol) are often used to restore growth rate and feed efficiency in castrated animals. The applied objective of our research is to develop a vaccine that will suppress testicular growth and function in livestock while enhancing gain and feed efficiency. Our long-term goal is to develop alternative management procedures that will eliminate the need for physical castration and supplemental administration of growth-promoting compounds.

Testicular development and function is the product of a hormonal cascade which begins with the release of a hormone from the brain called gonadotropin-releasing hormone (GnRH). GnRH stimulates the release of the gonadotropic hormones (luteinizing hormone [LH] and follicle stimulating hormone [FSH]) from the anterior pituitary gland which, in turn, increase testicular growth in prepubertal animals and stimulate sperm production and testosterone release in adults. We interrupt the hormonal cascade by vaccinating livestock against GnRH so the animals develop antibodies against GnRH. The antibodies make GnRH ineffective, so release of LH and FSH is reduced and testicular development and function are suppressed.

Our field work has demonstrated the effectiveness of immunocastration as an alternative to physical castration in livestock. When compared to bulls of similar breeding and age, scrotal circumference, testis weight, and levels of testosterone in the blood were significantly reduced in bulls vaccinated against GnRH as calves. Their conformation and appearance were significantly less masculine than those of unvaccinated bulls, and their carcasses were more like those of steers.

An additional practical benefit of immunocastration is that animal growth is not adversely affected. That is, the slaughter and hot carcass weights of vaccinated and unvaccinated bulls were comparable. This is in marked contrast to the effect of physical castration on growth. Our results showed that the slaughter and hot carcass weights of steers were significantly lower than comparable weights in bulls of the same breeding and age.

In summary, these results indicate that immunocastration is an effective and humane alternative to physical castration of livestock. Immunocastration suppresses testicular development and function in bull calves and ram lambs. Although final testicular size is dramatically reduced and testosterone secretion is significantly depressed in vaccinated animals, low levels of testosterone release continue. This residual level of testosterone secretion has anabolic effects that eliminate the need for supplemental use of foreign anabolic agents. In addition, immunocastration eliminates the stress and growth setback that usually accompanies physical castration. Thus, immunocastration is a practical alternative management procedure that addresses two important concerns of livestock producers in California, animal well-being and product quality.

Dr. Adams teaches ANS 140, Management of Laboratory Animals; and EDO 240, Biochemical Endocrinology. Cindy Daley is a doctoral student in the Endocrinology Graduate Group, Betty Adams is a Staff Research Associate, and Hirofumi Sakurai is a Postdoctoral Fellow.

PRODUCTION AND IDENTIFICATION OF TRANSGENIC BOVINE EMBRYOS

Gary B. Anderson

Transgenic animals contain as a permanent part of their genetic information a gene (sequence of DNA) that was experimentally inserted into the genome instead of obtained through natural breeding. Gene transfer techniques offer the potential to introduce a single gene in one generation without also transmitting undesired genes. Based on successes with transgenic mice, researchers have attempted to produce transgenic dairy cattle. Due to a variety of conditions, including long gestation periods, long generation intervals, and expense of producing embryos, success rate for producing transgenic dairy cattle is low and costs are high compared to those associated with transgenic laboratory mice.

Researchers at UC Davis are working collaboratively to develop and combine procedures that will allow efficient production of transgenic dairy cattle.

Researchers at UC Davis are working collaboratively to develop and combine procedures that will allow efficient production of transgenic dairy cattle. Transgenic calves are identified as embryos, *before* they are transferred to a recipient cow for development to term. Savings in time, labor, and expense accrue by eliminating non-transgenic embryos early in the process. The scheme being used is as follows:

Bovine ova are fertilized *in vitro* and then microinjected with the foreign gene. Embryos are allowed to develop for 5 days, and then a biopsy of several cells is removed. DNA is isolated from the biopsied cells and analyzed for presence or absence of the injected gene using PCR (polymerase chain reaction) procedures, which are designed to detect a specific DNA sequence in a small number of cells. If the gene is present in the biopsied cells, the resulting calf may also carry the gene. Once identified, transgenic embryos can be transferred to recipient females or frozen in liquid nitrogen for subsequent transfer.

The California Milk Advisory Board and the California Dairy Foods Research Center have supported development of these procedures for use with casein genes. This research requires collaboration of researchers with different expertise. Collaborators include Dr. Juan Medrano and Dr. Jim Murray (molecular geneticists), Dr. Esmail Behboodi (Postgraduate Researcher in Embryology), and Simon Horvat and Shelley House (Graduate Students), all from the Department of Animal Science. Dr. Bob BonDurant and Dr. Joan Rowe, Department of Reproduction, School of Veterinary Medicine, carry out the transfer of transgenic embryos to recipient cows.

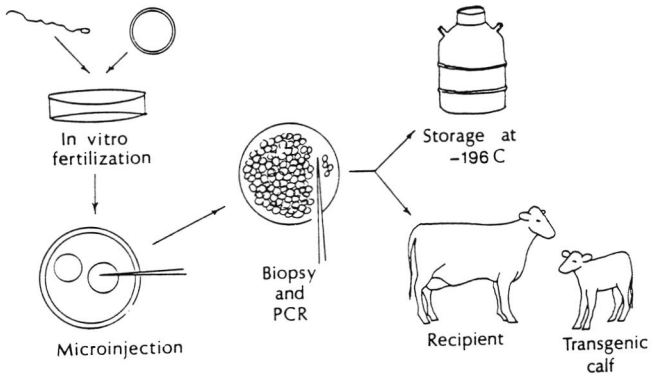


Figure 1. Production of transgenic cattle.

Dr. Anderson teaches PHS 121 and PHS 121L, Physiology of Reproduction; PHS 220, General and Comparative Physiology of Reproduction; and ANS 290, an Animal Science Seminar.

METHANE EMISSIONS OF RUMINANTS IN THE UNITED STATES

R. Lee Baldwin

A dynamic, deterministic, mechanistic model of dairy cow digestion and metabolism developed previously was revised, and additional analyses and evaluations of the model were undertaken. The model was generalized to enable evaluations of a broader range of animal weights and stages of maturity, including weaned calves, fattening steers, and lactating cows. The model was also revised to evaluate a wider range of diets, from poor quality forages to high-quality grain-based feedlot rations. The following changes were made to gain these capabilities: initial conditions, such as weight of body (largely muscle and skeleton), viscera, carcass fat, and gut fill were scaled to empty body weight; parameter values for metabolic equations were scaled to metabolic body weight ($W^{0.75}$); separate equations for hemicellulose and cellulose were added because their fermentation products differ and affect methane emissions; and, separate hydrolytic rate constants for hemicellulose and cellulose from grasses, legumes, and silages were developed.

To evaluate the model, a challenge data set of 34 different rations was developed from the literature. The data set included diets that ranged in quality from 1.6 to 3.1 Mcal/kg of ME. Respective r^2 values for the regression or best fit lines are 0.85 and 0.60, indicating good agreement. The agreement, in both cases, is essentially equal to experimental variance, and no systematic bias is evident. To develop estimates of methane emissions, the following animal types were defined for the cattle population: Dairy-replacement heifers 12 months of age, replacement heifers 12-24 months of age, and mature dairy cows (over 24 months of age); beef-replacement heifers 0-12 months of age, replacement heifers 12-24 months of age, mature beef cows (over 24 months of age), heifers and steers grown for slaughter, and mature bulls. Due to their small number, mature dairy bulls were not evaluated. Dairy calves not kept as replacements were included in the total for heifers and steers grown for slaughter.

Representative diets and management systems for each type of animal were defined for five regions of the U.S. (North Atlantic, South Atlantic, North Central, South Central, and West), and separate simulations were run. Estimates were also developed for sheep, goats, pigs, and horses. The total estimate for U.S. cattle of 5.5 Tg/y agrees very well with the early estimate of Crutzen (5.5 Tg/y), is a bit lower than the estimate of 6.0 Tg/y of Johnson, and is significantly above the estimate of 3.96 Tg/y presented by Beyers. The real advantage of the approach utilized herein, as compared to those used by others, is that we can evaluate potential benefits arising from alternative mitigation strategies—diet formulations, e.g. fat supplementation, ionophores, rBST, alternate management programs—on methane emissions and animal performance while earlier approaches cannot. The estimates generated in this study were used in the development of a recent CAST publication to estimate that methane emissions from U.S. agriculture contribute only 0.4% of total global (greenhouse) forcing by CO_2, CH_4, and NO_2 and in an EPA report to congress (in press) on global warming. Further, the model was used by a subcommittee of the NRC committee on animal nutrition to illustrate how dynamic mechanistic models can be used to evaluate effects of previous and current feeding practices on subsequent animal performance and, thus, improve on current NRC publications on feeding and management of livestock.

Dr. Baldwin teaches ANS 124, Lactation; NUT 202, Advanced Nutritional Energetics; NUT 254, Applications of Systems Analysis in Nutrition; NUT 256, Nutritional and Hormonal Control of Animal Metabolic Function; and PHS 205A, Intermediary Metabolism of Animals.

"PCDAIRY," A RATION FORMULATION AND ANALYSIS PROGRAM
Don L. Bath

"PCDAIRY" is the first in a series of ration formulation and analysis computer programs developed by UC Davis Animal Science Extension. It consists of seven individual program modules:

1. **MAXIMIZE** - This module formulates a ration for lactating cows that maximizes income above feed cost.
2. **LC** - This module formulates a least-cost ration for lactating or dry cows.
3. **GROWING** - This module formulates a least-cost ration for growing dairy heifers or bulls.
4. **ANLSIS-L** - This module calculates the nutrient content of a ration being fed to lactating cows, compares it with National Research Council nutrient standards, and lists the amount of milk that is possible from the ration and the limiting nutrients.
5. **ANLSIS-G** - This module calculates the nutrient content of a ration being fed to growing dairy heifers or bulls, compares it with National Research Council nutrient standards, and lists the amount of weight gain that is possible from the ration and the limiting nutrients.
6. **FEEDLIST** - This module allows the user to customize a list of feed ingredients for use in any of the above programs.
7. **DELIVERY** - This module is a spreadsheet program that generates schedules for loading ration ingredients into a mixer for a specified number of cows, and for unloading of the mixed ration to a specified number of cows.

"PCDAIRY" was developed primarily as an educational tool for use by University of California Extension personnel and for classroom instruction of Animal Science and Veterinary Medicine students at UCD. Because many dairymen and allied industry personnel expressed interest in buying the program, however, it has also been made available to private industry.

CORN-SUNFLOWER SILAGE
Don L. Bath

Interplanting sunflowers with corn in the Pacific Northwest has resulted in silage with higher levels of protein and fat than corn silage alone, making it a more nutritious forage for dairy cattle. A field trial in Kings County conducted by Carol Collar, Extension Dairy Advisor, with cooperation from D.L. Bath and E.J. DePeters, compared yields and chemical composition of sunflowers alone, two combinations of sunflowers interplanted with corn (2/3:1/3 and 1/3:2/3), and corn-alone silage. The results are shown in the table below.

In conclusion, it was determined that interplanting corn and sunflowers for silage resulted in less dry matter, crude protein, and crude fat yield per acre than corn alone under the hot, arid conditions of Central California. The higher percentages of crude protein and fat in sunflowers alone or in combination with corn did not compensate for tremendously lower yields compared to corn-alone silage.

	Dry Matter		Protein		Fat	
	(lb/acre)	(%)	(lb/acre)	(%)		(lb/acre)
Corn alone	20,460[a]		7.9[a]	1,620[e]	3.1[a]	645[e]
1/3 Sunflowers	16,200[b]		8.4[a]	1,362[e,f]	3.7[a]	596[e]
2/3 Sunflowers	11,760[c]		10.0[b]	1,183[f,g]	3.6[a]	431[e]
Sunflowers alone	6,600[d]		15.1[c]	992[g]	7.0[b]	469[e]

[a-g] Numbers in the same column followed by the same letter do not differ at $p<.01$ (a,b,c,d), or $p<.05$ (e,f,g).

ANALYSIS OF SPERM FERTILITY BASED ON SPERM'S ABILITY TO INTERACT WITH THE EGG

Trish Berger

Fertile male farm animals vary greatly in their fertility. This variation is obvious when equal numbers of sperm from two males are mixed and inseminated into a group of females. The variation almost certainly contributes to reduced productive efficiency when sperm numbers are limited. Until now, these differences could be detected only with breeding experiments; laboratory analyses of semen samples were unable to predict these differences. We have adapted a recently proposed bioassay of sperm fertility, which evaluates the ability of the sperm to interact with the surface of the egg (the egg plasma membrane), to pig and goat sperm. The outer coating of hamster eggs, the zona pellucida, is removed with an enzyme trypsin. Sperm from other species can then bind to the egg plasma membrane and fuse with the membrane, and the sperm nucleus decondenses inside the egg. Although the sperm cannot progress further, these events mimic the early steps of sperm-egg interaction during fertilization. Using this bioassay, we can predict the relative fertility of fresh semen and stored semen from the pig and frozen goat ejaculates quite accurately (correlation of 0.9; $p < 0.0001$ for stored boar semen).

The high correlation of this bioassay with fertility further suggests that the sperm's ability to interact with the egg surface is more limiting than the sperm's ability to reach the site of fertilization. Our laboratory is currently examining the molecules on the sperm surface that interact with the egg plasma membrane and with the zona pellucida. Our procedure is to isolate the membrane covering the sperm based on differences in density between the membrane and other parts of the sperm cell using an ultracentrifuge. The membrane is then solubilized and the different proteins in the membrane separated by molecular weight using gel electrophoresis. The separated proteins are transferred to sheets of nylon, which are then exposed to solutions containing tagged egg plasma membrane molecules or tagged zona pellucida molecules. The tagged molecules bind to the sperm membrane molecules for which there is an affinity. After the solutions of tagged molecules are rinsed away, the sperm plasma membrane molecules with an affinity for the egg plasma membrane or zona pellucida are determined by observing the tagged molecules bound to the sperm proteins attached to the nylon sheet (Fig. 1).

Kendall Ash and Cathy Horner have discovered as part of their graduate student research projects that several different molecules on the sperm surface have an attraction for the egg plasma membrane and for the zona pellucida. All of these molecules are potentially involved in the interaction of the sperm and egg. There are differences in the quantities of these molecules among ejaculates with different abilities to interact with the egg. We are examining whether we can use these differences to improve the analysis of fertility and perhaps improve sperm fertilizing potential.

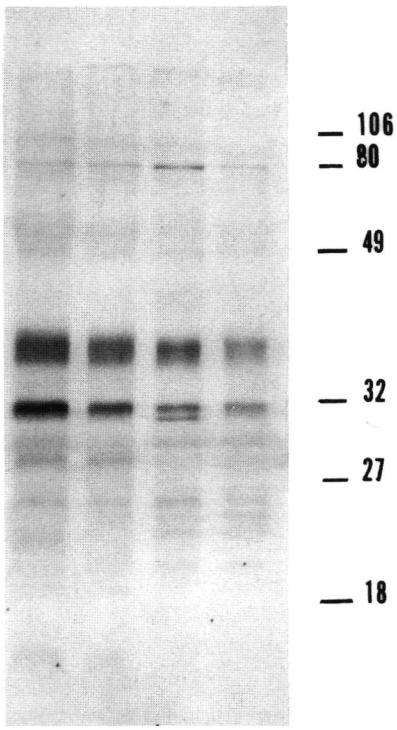


Figure 1. Each horizontal track contains sperm plasma membrane from a single boar. The vertical bands represent the molecules with an affinity for the zona pellucida. Ejaculates show obvious differences in these molecules (C.M. Horner, Thesis Research).

Dr. Berger teaches ANS 2, Introductory Animal Science; ANS 143, Pig and Poultry Care and Management; and PSH 222, Mammalian Gametogenesis and Fertilization.

DAIRY PERIPARTURIENT DISEASE SURVEILLANCE PROJECT
Steven L. Berry

Problems at or around the time of calving (periparturient) contribute to cow and calf morbidity and mortality, increased veterinary costs, and poor cow fertility. As milk yield increases, cows are under more metabolic stress, especially during early lactation. Getting cows bred back early requires better nutrition and reproduction management and is critical for dairy profitability. This project will help identify the relationships between management and disease and to subsequent reproductive performance and milk yield. We will have large numbers of records on well-managed, high-producing, commercial herds in California which should allow us to evaluate and determine optimum reproductive performance on these dairies.

The periparturient disease surveillance project is designed to collect calving, health, and milk yield data from large, commercial dairies.

We also hope to identify management practices that can decrease the incidence and severity of problems or help identify cows at high risk of further problems. The periparturient disease surveillance project is designed to collect calving, health, and milk yield data from large, commercial dairies. Data is currently being collected and monitored from 10 California dairies milking 550 to 1650 cows each. Personnel on the cooperating dairies enter reproductive and health information daily. We are monitoring data on calving difficulty, number of calves born, calf livability, calf sex, retained placenta, milk fever, uterine infections, mastitis, cystic ovarian disease, lameness, and left displaced abomasum. We also monitor reproductive events and test-day milk yield data. Files are picked up from the dairies monthly and processed at UC Davis. We keep data on cows that leave the herd as well as accumulate multiple lactations on cows.

The objectives of the project are to quantify: 1) the relationships of previous lactation milk yield on disease occurrence; 2) the relationships of diseases to each other; and 3) the effect of single or multiple diseases on fertility and milk yield. This project involves various levels of collaboration with dairy owners and managers, dairy farm advisors, consulting nutritionists and veterinarians, and faculty from the School of Veterinary Medicine. All collaborators receive monthly reports on reproductive status and disease incidence on their dairies and quarterly reports showing reproductive status and disease incidence on all dairies.

"COWBOSS" AND "PORKPLANNER"
Steven L. Berry

"COWBOSS" and "PORKPLANNER" are computerized record keeping programs designed to help commercial beef and swine producers to keep production records and make rational business decisions. The programs were developed and extensively beta-tested on commercial farms before being reviewed by academic personnel in the University.

"COWBOSS" and "PORKPLANNER" are designed to allow the producer maximum flexibility in data entry, report generation, and data analysis without requiring a high level of computer expertise. Copies of these programs are being used nationally and internationally by commercial beef and swine producers and educational institutions.

MAJOR GENES FOR GROWTH AND REPRODUCTION

G. Eric Bradford

For the first 50 years of the scientific era of animal breeding, 1930 to 1980, the general view was that genetic variation in production traits was the result of many genes, each with small effects. Breeding methodologies were developed to utilize this quantitative genetic variation, and their use has resulted in greatly increased rates of genetic improvement in milk production, growth rate, and feed efficiency in livestock. The possibility of genes with individually large effects was generally ignored by animal breeders trained in quantitative animal genetics. Some genes with large effects that were discovered usually had some deleterious effects (*e.g.*, double muscling in cattle) and were not considered as having potential for animal improvement.

A gene that increases postweaning growth rate by 50% without increasing birth or weaning weights or changing body composition, and increases efficiency of feed conversion by 25%, is surely of interest in meat animal production.

To study the direct and correlated responses to long-term selection for growth rate in a mammalian species, I had been selecting for post-weaning gain in laboratory mice. Briefly, postweaning gain doubled in 20 generations, but reproductive fitness (fertility and pre-natal viability) declined sharply. The response in growth rate was fully explained on the basis of classical quantitative genetic assumptions. However, in about generation 25 in one of two high-growth lines, we noticed an occasional super-large mouse that gained at about three times the control line rate. Crossing these mice with an unrelated strain and producing an F_2 showed that the "giant" mice were homozygous for a single recessive gene which increased growth rate about 50%. The gene (designated *hg* for high growth) has now been put into many different genetic backgrounds and has about the same proportionate effect in large or small, inbred or outbred stocks.

Work by Drs. Calvert and Famula and other colleagues in the Department has shown that *hg hg* animals have markedly increased efficiency of energy utilization but do not differ from their normal (+ +) contemporaries in body proportions or composition. Dr. Medrano has shown that *hg hg* animals have *lower* growth hormone levels but much higher levels of IGF-1, another important hormonal regulator of growth.

Other genes with large positive effects on performance traits in animals have been reported recently, including several "major genes" for prolificacy in sheep. Are such genes potentially useful in livestock improvement? The answer of course depends on the secondary as well as the primary effects of the particular gene and how it is used. An important advantage of such genes is that they can be transferred into different genetic stocks by backcrossing or, ultimately, with transgenic technology, without the associated background genotype.

The *hg* gene in mice has some intriguing possibilities. If the gene can be localized and cloned, as seems probable, it could be transferred into cattle, sheep, or

pigs. A gene that increases post-weaning growth rate by 50% without increasing birth or weaning weights or changing body composition, and increases efficiency of feed conversion by 25%, is surely of interest in meat animal production. Unfortunately, the gene has fairly serious negative effects on fertility, and if these effects transferred with it, its net effect on livestock production would be negative. However, it is known that in some cases transgenes can be regulated to express only in certain situations. If the *hg* gene were put into, say, cattle and regulated so that it was not expressed in the breeding female but could be turned on during the calf's postweaning period, it could lead to a marked increase in efficiency of lean beef production.

Whether or not this scenario is ever realized, such genes are extremely useful in studying the regulation of growth or other production processes and may contribute indirectly, if not directly, to our ability to increase animal production efficiency and product quality.

Figure 1. At left is the *hghg* (mutant) mouse; at right, its *Hg*-(normal) littermate.

Dr. Bradford, Professor Emeritus and former Chair of the Department of Animal Science, is Director of the Animal Agriculture Research Center.

HUMANE METHODS FOR MEASURING BODY COMPOSITION OF LIVE SUBJECTS

Dan L. Brown

Eight species have benefitted from the development and refinement of accurate but harmless methods of monitoring the chemical composition of their living bodies. The dilution of deuterium oxide (non-radioactive heavy water, called D_2O) by body water and the ability of lean tissue to conduct the flow of electrical current (TOBEC) have been utilized to estimate the fat, water, protein, ash, and energy content of goats, sheep, cows, pigs, rabbits, humans, deer, and, recently, cats.

Now that safe, accurate methods of body composition determination are available, it is no longer necessary to slaughter or cause pain to animals in order to find out what they are made of.

The D_2O dilution method requires that a precisely weighed dose of D_2O be injected or ingested by the subject and a series of blood, milk, saliva, or urine samples be taken over a period of hours or days to reflect the concentration of D_2O in body water. All water is completely extracted from these samples and retained for infrared spectroscopy. The amount of body water present can be calculated from the dose and body water concentration of D_2O. Equations that predict body composition were then developed by the mathematical comparison of real body composition determined from animals at slaughter with live body weight and body water (or more precisely speaking, D_2O dilution space) measured just before slaughter. Now the prediction equations can replace slaughter in the determination of body composition, if experimental or field conditions are similar to those present when the equations were created.

The TOBEC (Total Body Electrical Conductivity) methods were validated in a similar manner. Dr. Nancy Keim of the USDA Western Human Nutrition (Presidio of San Francisco) collaborated on these experiments. The TOBEC machine scans the subject on a sled passing through a weak electrical field. Perturbations of that field caused by lean tissue are measured at 64 points on the animal's body and a computer provides various indices of that electrical conductance.

These breakthroughs permit repeated, meaningful assessments of the nutritional status of individual living animals that are impossible by dissection. In collaboration with the USDA Human Nutrition Center in San Francisco, this laboratory has shown that improvements in the condition of cystic fibrosis victims can be safely monitored. These new body composition methods have also permitted scientists to determine how much milk mothers provide for their young and to make low-cost estimates of the true (net energy) values of feeds for dairy cattle, goats and swine.

Now that safe, accurate methods of body composition determination are available, it is no longer necessary to slaughter or cause pain to animals in order to find out what they are made of.

Dr. Brown teaches ANS 102, Limited Resource Animal Agriculture; and NUT 115, Animal Feeds and Nutrition.

METABOLISM OF NATURALLY OCCURRING FEED TOXICANTS

Dan L. Brown

Virtually all plants contain chemicals and structures which protect them from predation by fungi, insects, and larger herbivores. These secondary plant compounds may be toxic to our domestic livestock and enter the human food chain. This project has focused on canavanine (a toxic amino acid found in alfalfa sprouts and many other legumes), urushiol (the active principle in poison oak), and sparteine (a quinolizidine alkaloid found in Scotch broom).

In a study recently conducted at the Sierra Foothill Research and Extension Center, urushiol did not appear in the milk or urine of goats fed poison oak, but 9% of the dose did appear in the feces and only then in a more saturated state. We are currently studying how the rumen microbes and liver enzymes may bring about this extensive catabolism.

The effects of dietary canavanine on autoimmune disease (lupus erythematosus) and reproduction are the subjects of current long-term studies. So far, we have found that the canavanine in two ounces of alfalfa sprouts per day for a month is not adequate to trigger auto-antibodies in women, but 0.68% canavanine added to the diet prevents mice from carrying pups to term. The existence of mouse auto-antibodies and altered protein structure after 14 months of feeding 1% canavanine is currently under investigation.

Scotch broom is an invasive exotic legume species that has taken over more than 600,000 acres of Northern California. This plant contains sparteine and other quinolizidine alkaloids. Some alkaloids in this class are neurologically active and others have been implicated as a cause of birth defects. Preliminary experiments indicate that goats can eat Scotch broom without apparent ill effects, that at least some goats catabolize metabolize sparteine at least to the deoxy-catabolites, and that either sparteine is not passed into the milk or the lower limits of detection from the TLC screens employed to date are not adequate to pick it up. More quantitative, accurate and powerful HPLC methods are under development at this time.

Figure 1. Experimental subject at poison oak feeding station. Urushiol, the active toxicant in poison oak, did not appear in the milk or urine of goats fed this plant.

PROTEIN AND ENERGY METABOLISM IN HYPERMETABOLIC STATES

Christopher C. Calvert

Animal production processes (growth, lactation and reproduction) and responses to immunological challenges are physiological states supported by hypermetabolic activity. The homeorhetic controls which alter nutrient partitioning during these hypermetabolic states are poorly understood. Future increases in animal production will be predicated on an understanding of the controls and limitations for supplying nutrients from the diet and body stores in support of productive processes. My primary research interest is protein and energy metabolism during hypermetabolic states such as growth or lactation.

We are able to demonstrate that traditional empirical methods for describing efficiency of growth and nutrient partitioning are not adequate to describe growth processes quantitatively. We are proving that protein metabolism cannot be described by empirically derived models but rather requires models with equations that are mechanistic in nature. We have had some success using this approach relative to beef cattle growth.

We are conducting similar work to improve quantitative and mechanistic descriptions of the effect of lactation on protein and energy metabolism. We have shown that the mammary gland utilizes amino acids from both plasma and red blood cells in support of lactation and proven that previous estimates of blood flow per unit of milk produced are underestimated. The implications are far reaching, as previous attempts to describe efficiency of lactation in dairy cows have used mammary gland blood flow rates which are too slow per unit of milk production.

Further, it is obvious that the cells in the blood do carry amino acids to organs for metabolic purposes, so it is likely that using plasma amino acid concentrations, which are routinely measured in a variety of research efforts, does not provide a complete picture of metabolic changes and may in fact lead a researcher to reach flawed conclusions.

To increase the intensity of our approach to the problem of hormonal control of milk protein gene expression, we have moved into cellular and molecular biology. We are having success with a bovine mammary cell line in that we are able to induce milk protein synthesis and secretion in these cells and show that the metabolic activity of these cells can be regulated by hormones.

As a result of this research, I have become aware that quantifying protein synthesis requires accepting assumptions that are contrary to actual biology. As a result we are developing strategies for improved quantification of protein synthesis. The data resulting from this effort have led to an altogether new appreciation for the channeling of amino acids to specific metabolic fates. Application of this improved understanding will revolutionize current descriptions of protein turnover and amino acid trafficking by advancing the current theoretical framework relative to amino acid/protein metabolism.

Dr. Calvert teaches ANS 135, Experimental Biochemistry Laboratory; NUT 110, Principles of Nutrition; ANS 235, Advanced Techniques in Animal Nutrition Research; and NUT 257, Selected Topics in Nutritional and Hormonal Control of Nitrogen Metabolism.

CRUSTACEAN GROWTH HORMONES

Ernest S. Chang

Research conducted by our group involves biochemical and physiological aspects of growth, development, and reproduction of crustaceans and other marine invertebrates. In particular, we have determined the amino acid sequence of the lobster molt-inhibiting hormone (MIH) and crustacean hyperglycemic hormone (CHH). After dissecting glands and purifying with HPLC, we sequenced the peptide hormones. These two peptides, MIH and CHH, which comprise a unique neuropeptide hormone family, are so closely related to each other that they share 96% sequence identity and have blocked N-terminals. We are now investigating the hormone structure and function and mode of action of MIH. This important regulator of crustacean growth has economic importance for the efficient production of crustaceans.

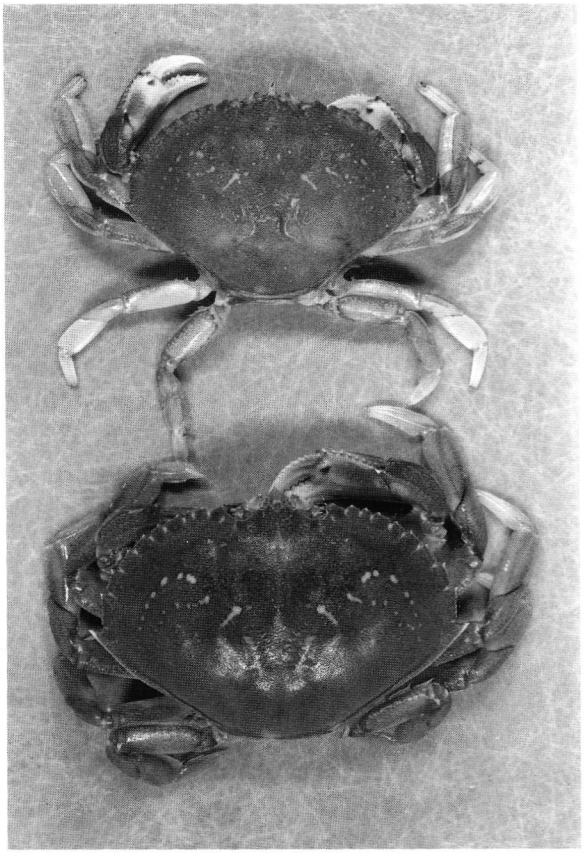


Figure 1. Old exoskeleton (top) of a newly molted Dungeness crab (*Cancer magister*) (bottom). Molting, a prerequisite for growth, is controlled by several different hormones.

We have just completed the construction of a cDNA library of the lobster eyestalk sinus gland. We isolated total RNA and purified the polyA mRNA fraction. The cDNA was made against the mRNA and inserted into a lambda vector. A library with a high titer was obtained. We are currently screening this library with oligonucleotide probes generated from our knowledge of the amino acid sequence of MIH. With the information obtained, we hope to learn about the influence of the environment (temperature, photoperiod, crowding, etc.) on the molecular action of this growth regulator.

We are also looking at a number of other hormones involved in lobster, crab, and shrimp physiology. These hormones include the steroid molting hormone (20-hydroxyecdysone) and a novel juvenile hormone-like factor (methyl farnesoate). The interaction of these factors indicates that the hormonal regulation of molting is much more complex than originally thought.

Dr. Chang teaches PHS 120, Comparative Physiology: Endocrinology; BIS 121 and BIS 121P, Physiological Adaptation of Marine Organisms, and Advanced Laboratory Topics; and BIS 123, Undergraduate Colloquium in Marine Science.

MECHANISMS OF FERTILIZATION AND EARLY DEVELOPMENT IN THE MARINE SHRIMP, *Sicyonia ingentis*

Wallis H. Clark

Our laboratory, over the last 15 years, has worked to unravel the mechanisms of fertilization and early development in the marine shrimp, *Sicyonia ingentis*. We now have an understanding of the morphology, physiology, and biochemistry of both male and female gametes and the changes that occur during gamete interaction and fertilization. Our studies have revealed that fertilization is unique in this species when compared to fertilization in more commonly studied species. For example, in the most commonly studied marine invertebrates fertilization occurs within a matter of seconds of gamete contact, while in *S. ingentis* fertilization takes approximately 30 minutes. This extended period required by *S. ingentis* gametes provides protracted windows in which to study the various cellular events of fertilization.

Two questions actively being explored are: (1) how does the mechanism of oocyte activation in *S. ingentis* compare to that in other systems, and (2) by what mechanism(s) is polyspermy prevented in *S. ingentis*?

The oocytes of *S. ingentis* are activated by sea water Mg^{2+}, not sperm, to undergo an internal Ca^{2+} release, rounding up (cortical alterations), the resumption of meiotic maturation, the recruitment of cortical vesicles, and the elevation of a hatching envelope. The completion of this activational sequence takes approximately 40 to 45 minutes. These results are somewhat surprising since the general belief is that oocyte activation (1) is initiated by a sperm and (2) involves the release of internal Ca^{2+} stores only in the deuterostomes (*e.g.*, vertebrates, sea urchins, and ascidians), not the protostomes (*e.g.*, molluscs and arthropods). We are currently examining the mechanism by which Mg^{2+} activates *S. ingentis* oocytes, and our results should provide valuable information on a process that until now has not been characterized for any protostome system.

During the 30 minutes between sperm binding to the oocyte and fertilization, sperm undergo a protracted acrosome reaction resulting in one sperm fusing with the oocyte. Since hatching envelope elevation does not occur until 10 to 15 minutes after sperm entry, oocytes must possess an early block to polyspermy. Since there is no evidence for an electrical fast block, the nature of this block is not known. Similar questions exist concerning polyspermy blocks in the eggs of vertebrates and cnidarians, and it is hoped that *S. ingentis* may provide insight into heretofore undescribed mechanisms for the prevention of multiple sperm entry at fertilization.

Other interests of our laboratory include the mechanisms of sperm capacitation and early development of the embryo.

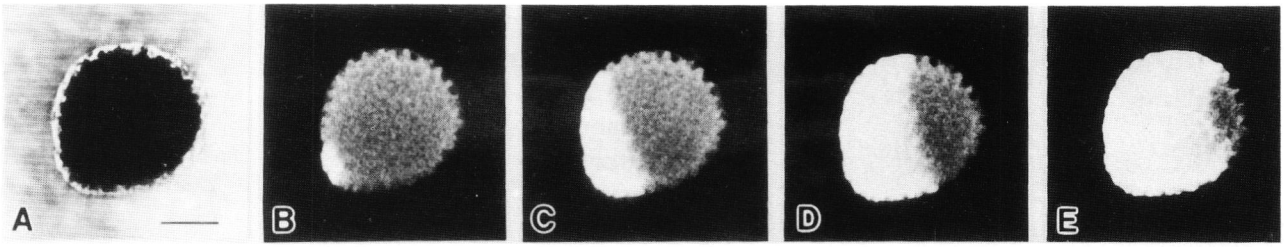


Figure 1. An unactivated egg in Mg^{2+}-free sea water injected with fluorescent Ca^{2+} indicator Fluo-3, and then monitored during activation with added $MgCl_2$ using laser scanning confocal microscopy. (A) Transmitted light image of the oocyte; bar = 100 µm. (B-E) Confocal images showing progression of Ca^{2+} activation wave; B = 0 time (wave first detected); C = 5 sec; D= 13 sec; E = 23 sec.

Dr. Clark teaches ZOO225, Biology of Fertilization; BSC 120, Developmental Biology of Marine Invertebrates; BSC 120P, Developmental Biology of Marine Invertebrates/Advanced Laboratory Topics; and BSC 123, Undergraduate Colloquium in Marine Science.

POPULATION DYNAMICS OF BRINE SHRIMP IN THE SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE

Douglas E. Conklin

Although the primary focus of aquaculture nutrition is development of formulated feeds, the use of live or fresh feeds is often desirable and in some cases, such as larval fish and crustaceans, essential. Brine shrimp, a small (~1 cm long) filter-feeding crustacean of the genus *Artemia*, is one of the most popular of these feeds. Use of live and frozen *Artemia* by the ornamental fish market is estimated to exceed 4,000 metric tons a year.

One of the most important features of brine shrimp life cycles for aquaculturists is their production of resting eggs or cysts. These cysts can be collected in great numbers and, once dried, can be kept for years. The very small (200,000 to 350,000/g) cysts are typically packaged in airtight containers and sell for about $8 to $10 per pound. Cysts are readily hatched in gently aerated seawater over a 24 to 48 hour period and thus represent a convenient "off-the-shelf" live food source for aquaculturists. Used extensively in the larval culture of marine shrimp throughout the world, world-wide demand for *Artemia* cysts is presently estimated to be around 350 metric tons per annum.

Brine shrimp are found in isolated hypersaline bays and lakes around the world where salinities exceed 45 ppt and can go as high as 340 ppt (approximately 1.5 to 10 times the salinity of seawater). Because of their tolerance of high salinity, brine shrimp are often associated with commercial salt production and the salt works of San Francisco Bay have long been an important source of brine shrimp adults and cysts. Since these ponds and their brine shrimp populations also serve as a key source of food for migratory shore birds, in 1977 many of these ponds were incorporated into the San Francisco Bay National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. The management goals of the agency thus encompass protection of the habitat for the benefit of migratory birds, continuing salt production and commercial harvest of live brine shrimp and cysts.

Surprisingly, little information is available about the ecology of the salt ponds and so a research project was initiated recently to identify critical factors in understanding brine shrimp productivity and processes that control population growth. With the assistance of two graduate students, field and laboratory studies are being carried out to determine the impact of various environmental factors as well as the algal food supply of the ponds on brine shrimp reproduction and growth. Preliminary work suggests that although within a single pond brine shrimp productivity can be predicted using a combination of temperature and salinity data, harvest differences between ponds is most likely dependent the algal food supply. These various parameters are being incorporated into a computer model which eventually will be used to provide a rational basis for sustainable management techniques within the refuge.

Dr. Conklin teaches ANS 18, Introductory Aquaculture; ANS 119, Invertebrate Aquaculture; and NUT 124, Nutrition and Feeding of Finfish and Shellfish.