The little girl pictured on the cover carries the "flag" of kwashiorkor. Her head dramatically shows the result of severe protein deficiency. Before weaning, she was getting adequate protein in her mother's milk. She then had to exist on the diet of her parents (a period of time indicated by the light band in her hair). Fortunately, she received protein therapy before the disease took its full toll.

Malnutrition doesn't always provide such easily identified evidence. Especially among the affluent, it tends to be more subtle—and therefore difficult to diagnose. The article beginning on page 67 points out some of the possible ramifications of this subtle malnutrition and proposes a way to help people avoid them.
Malnutrition doesn’t play favorites. It isn’t a prerogative of the poor—nor is it confined to other nations or other states. No matter where you live, how much you spend on your weekly food budget, or how carefully you read labels, up to 30 percent of the calories you eat each day are "empty." That means they carry no food value—they are as lacking in nutritional benefit as the calories in a bottle of pop.

Why this is so, and whether anything can be done to avoid even borderline malnutrition are questions of prime concern to members of land grant institutions such as Utah State University.

PHYSICAL CONSEQUENCES OF NUTRIENT DEFICIENCY

True, in Utah, you may seldom encounter an individual obviously suffering from severe malnutrition. But that isn’t the signal for complacency. Borderline malnutrition may not be spectacular, but its subtle effects can rob you of the energy to enjoy life.

Deficiencies of certain nutrients are difficult to diagnose. Besides, if a diet is deficient in one factor, it probably lacks several, and the body generally responds to such a situation with diverse symptoms. And of course, in some cases, the diet may be adequate but the individual may simply not be able to "use" some of its components.

Fortunately, some specific physical defects characterize deficiencies of certain individual nutrients. Without being exhaustive, scurvy results from a vitamin C deficiency; beri beri from a shortage of vitamin B₁; anemia from iron, folic acid or vitamin B₁₂ deficiency; visual difficulties are associated with insufficient vitamin A; rickets result from vitamin D deficiency; pellagra is caused by insufficient niacin and protein; and marasmus is a result of calorie deficiency (figure 1).

But outside of conspicuously de-

Figure 1. The light sensitive lesions of pellagra, a disease caused by a diet deficient in niacin and protein, are on the chest and hands of this man. It was first discovered in the Southern United States in the late 1930s.
prived households, the symptoms may be far less easy to recognize. Restricted growth and delayed development may be general consequences in youngsters suffering from poor nutrition. Of particular concern is the possibility that mental, as well as physical development may be impaired by nutrient inadequacies during critical stages of growth. One reason for the difficulty in diagnosing malnutrition centers are the thousands of chemical reactions that have to take place in millions of cells, just to keep each of us alive.

**THE MOLECULAR LEVEL OF DIGESTION**

The vitamins and the inorganic trace elements in foods we eat function in our bodies as co-factors in some of the chemical events that support life. These events typically also involve an enzyme, which acts as a catalyst (a chemical term describing a material that is essential to a reaction but isn't modified by it). In figure 2, an enzyme is catalyzing a reaction wherein compounds A plus B interact to yield C plus D, plus the unaltered enzyme. Conversions of this sort frequently also require co-factors such as a vitamin or a mineral or both. These "accessory" food factors must be in the diet in proper quantity, or various cell reactions will either malfunction or not function at all.

Obviously, an inadequate intake of any one of the accessory nutrients (vitamins, trace minerals, etc.) can greatly impair physiological functions. A seemingly minor nutrient deficiency thus could prevent the conversion of compounds A and B to compounds C and D. As illustrated in figure 2, this could equate with too much of A and B, and not enough of C and D. The eventual consequences could include various physical and/or psychological disorders whose cause might or might not be readily diagnosable.

**THE GENETIC INPUT**

Despite an adequate diet, an individual may be poorly nourished because of some genetic maladjustment, which generally operates at the cellular level. And since every one of us carries an average of seven genetic defects—this possibility isn't as esoteric as it may first appear to be.

Typically, a nutrition-oriented genetic defect involves an enzyme (figure 2). If we hypothesize a family with each of the parents (both of whom show no external signs of malnutrition) having only half the normal level of some vital enzyme, the children may be of three types with respect to the amount of that enzyme: (a) normal, (b) half level, or (c) none. Statistically, in disorders that are genetically recessive in pattern, the numbers of offspring would be expected to occur in the ratio of 1 to 2 to 1 for types (a), (b), and (c), respectively. Individuals of type (a) and usually of type (b) would not be adversely affected. However, the consequences to individuals of type (c), who have none of the enzyme, could be extremely critical, resulting from a nutrient imbalance within the tissues.

Perhaps the best known of the approximately 100 identified human genetic disorders is phenylketonuria. In this case, the afflicted child is born incapable of converting phenylalanine into tyrosine, two of the important amino acid constituents of the proteins. As a result, phenylalanine and other abnormal metabolic products accumulate in cells of the untreated individual. But the crucial phenomenon is the deficit of tyrosine and certain of its related metabolites. The consequences to the individual, if the disease is untreated, are disastrous. Intelligence, as measured by a standard test, is severely impaired (figure 3), head size is reduced, and hair color is abnormal. Fortunately, early diagnosis and treatment can offset many of the symptoms of phenylketonuria.

In many respects the visible effects of such genetic defects mimic those of an externally caused nutritional deficiency. For example, when you deprive your body of an important nutritional element, you generate defi-

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*Figure 2. If a critical enzyme were lacking in a person's body, the results could be devastating. Assume that compound C or D is needed for some vital cellular function and either cannot be formed from components of the diet, or is not provided by the diet itself. A block in the conversion of A and B to C and D could lead to a deficiency of C and D and an excess of A and B within the tissues. An abnormal accumulation of A and B within the cell may provide a toxic environment while a deficit of C and D is roughly analogous to a dietary lack of an essential nutrient, and could be expected to produce comparable consequences.*
ciencies of some compounds and excesses of others. Nutritional deficiencies, regardless of cause, may not inevitably produce severe bodily and mental impairments, but some limitation of an individual’s capabilities is always a potential hazard.

But deficiencies aren’t always the culprit in nutritional problems. Excesses can be as dangerous as deficiencies. Consider for example, the relation of food intake to cardiovascular disease.

**DIET AND CARDIOVASCULAR DISEASE**

A principal cause of death among American men is cardiovascular disease. More than half of the male population of the United States can expect to die as a consequence of this disorder. While the various causative factors are not fully understood, the more important ones include physical and emotional stress, smoking, physical exercise, diet, genetic factors.

The relationship of diet to cardiovascular disease is complex, and some of the proposed treatments border on the fadistic. Total calorie consumption is important since calories in excess of those expended for normal work and exercise are stored as fat. Hence, a just-adequate calorie intake in the form of foods supplying all of the essential nutrients is the ideal. In a family where attractive and tasty foods are a desirable and a routine part of the environment, it is not easy to restrict intake. The concerted effort of the entire family, but especially of the housewife, is needed if the adult male members are to achieve a balance between energy intakes and expenditures.

The character of the American diet has changed over the last few decades. Formerly about 20 percent of the calories consumed were derived from fat, now approximately 40 percent of the calorie intake is fat. Fat is unusually high in calories, containing 9 calories per gram, whereas carbohydrate and protein have only about 4 calories per gram. Thus, increasing the fat component of the average diet has greatly increased its calorie density, often decreasing its nutrient density.

There are those who argue that it is all right to eat unsaturated but not saturated fats. In this context, saturation simply describes the chemical status of the fat. Fats of animal origin are relatively more saturated in their natural form than are those of plant origin. Actually, however, many fats of plant origin (e.g., vegetable shortenings) become hydrogenated when processed and are thus...

**Figure 4.** The average age at which females experience their first menstrual period has declined in the developed countries at least 2½ years in the last century.
saturated when used by the body. Obviously, an arbitrary distinction of animal fats versus plant fats is invalid. For example, during the last two or three decades, while cardiovascular disease has been increasing, the total unsaturated fatty acid content of the American diet has also been increasing, paralleling the change in total fat. Therefore, to treat cardiovascular disease by simply substituting one “kind” of fat for another in the diet is risky. It is more rational to reduce the total calorie intake and to consume foods that have a high nutrient density coupled to a low fat density.

Much has been printed about regulating cholesterol intake. In reality, our bodies synthesize more cholesterol from the other foods we eat, than we are likely to consume directly. The blood cholesterol level is a good indicator of the risk of the individual for cardiovascular disease, but a concern for cholesterol intake in the food is less well founded. Since the calories we eat that are in excess of our maintenance and exercise needs can be (and often are) converted to cholesterol physiologically, the person in search of good health is best advised to be concerned with calorie rather than cholesterol counts.

Another kind of problem associated with abundant, if not excessive food intakes, is much more nebulous. It primarily affects the youth of affluent societies.

EFFECTS ON SIZE AND MATURITY

The kinds and quantities of food a child eats obviously affect his physical stature and physiological maturity (and, though not so obviously, his mental capacities). If the onset of menses in young women (figure 4) is used as an index of physiological maturity, for each ten years that have elapsed during the last century, physiological maturity has come three months earlier. In other words, the average child of today is maturing physiologically thirty months sooner than did his predecessor of a century ago. The possibility that improved nutrition is an important contributor to this physiological change cannot be ignored.

Paralleling the physiological changes, we have a well-documented increase in height. Each generation of college freshmen is taller than the preceding one. This also may be partially attributed to improved nutrition, although other factors could be involved.

Whether increased size and early physiological maturity are unmixed blessings, could be debated. The frustrations inherent in a physiological maturity that is out of phase with social and cultural responsibilities and expectations are being dramatized around the world by today’s young people. Denied the decisions of adulthood and required to have ever more education before they can function meaningfully in society, the young turn their whirlwind of energy to other ends.

Children living elsewhere in the world, especially in less well fed societies, differ from those in the United States with regard to size and maturity. They are generally smaller and mature physiologically at a later age, if they survive to adulthood (figure 5).

In economically depressed parts of this country, where a high proportion of the people are malnourished, children are smaller than the national average. Growth is inhibited, and ultimate size is limited. If physical stature were the only concern, the situation would be serious enough, but the evidence is increasing that such physical impairment may be coupled with mental and emotional disabilities. Hence, malnourishment and improvement of diet are crucial social issues throughout the world.

But how do we know for sure what constitutes adequate nutrition and who does or does not achieve it?
DETERMINING ADEQUACY OF NUTRIENT INTAKE

Over the past ten or fifteen years, the United States government, through an inter-agency group, has sponsored nutrition surveys in developing countries. These efforts have produced techniques that facilitate assessing the extent of malnutrition and nutrient deficits in populations.

Each survey team commonly includes specialists in medicine, biochemistry, nutrition, and food technology. Once an appropriate random population sample, or one that will emphasize a specific target group such as children or the economically disadvantaged, has been defined, the team goes to work.

Each member of a survey team obviously sees a different picture. The physician sees physical symptoms in individuals that are the consequences of inadequate nutrition during the previous year. Measurements made by the biochemist emphasize nutrient intakes of last week or last month. The nutritionist is concerned with what foods are being presently consumed. Hence, the findings of these three may not agree directly, but broad overall correlations generally can be found, and these are useful.

The food technologist gathers data on the food production, export and import characteristics of the country. Conclusions that are reached in regard to the inadequacy of specific nutrients are often substantiated by more than one team member.

THE SITUATION IN THE UNITED STATES

Comparable techniques have been used to determine the nutritional status of the population of the United States. A national nutrition survey initiated in 1968 has involved people in different localities in ten states, but results have been summarized only for Texas and Louisiana. The surveys of the other eight states, representative of the various regions of the United States, were completed only recently.

About 50 percent of the samples in Texas and Louisiana came from populations with incomes below $3,000 for a family of four. Also, a higher than normal proportion of some of the ethnic minorities were represented in these two surveys. Even so, an incredibly high proportion of those examined were found to have inadequate nutrient consumption. From 5 to 15 percent of the people surveyed were deficient in one or several of the nutrients. Anemia was a common finding, especially in women and children. Goiter was seen in as high as 5 percent of the population in some areas (figure 6). Deficient and low intakes of vitamin A, riboflavin, thiamin, and protein were seen in 5 to 15 percent of the individuals examined (figure 7).

While the data for the two states that were surveyed first seemed biased for low income groups, malnutrition was also found, although less frequently, in more affluent groups. Also, the preliminary summary of survey results from the other eight states indicates that the analyses from the first two states are broadly representative of the general population. Since we have the knowledge, technology, and foods to avoid scurvy,
goiter, night blindness, and stunting of growth, it is a national disgrace that we haven't done so. It is tragic that many citizens of the U.S. can't afford to purchase the appropriate foods. But it is incredible that even those with adequate resources do not necessarily achieve a balanced diet.

REGIONAL DIFFERENCES

The 1969 White House Conference on Food, Nutrition and Health was called partially in response to the analysis of the early findings of the National Nutrition Survey, and partially because officials were concerned about the nutrition and health practices in the United States. While the White House Conference documented the management of national food supplies from numerous points of view, the summary statement and recommendations to the President focused attention on the need for social action. Nothing has been done, however, to implement the continuous food surveillance program called for by the White House Conference.

At best, the commitment of the federal government to improving national nutrition ratings and maintaining the food supply is nebulous.

The nutritional problems of one region are not always the same as those of another. Even though our system of distribution is such that food is often grown in one region for consumption in others, there is some regional character to nutritional problems. Utah itself may well have unique problems. Although no comprehensive survey or study has been made of the state's population, there is reason to believe that economically disadvantaged and ethnic minority groups consume inadequate quantities of nutrients. Furthermore, people of all income brackets are subject to making unwise decisions when buying food, which may lead to borderline nutrient inadequacies. There is some interest and an obvious need in the state for a thorough examination of the nutritional status of the population. We're not likely to solve problems until they are defined.

FOOD HABITS

In addition, food habits are changing throughout the nation. A higher proportion of our diet is composed of prepared foods and food providing "empty" calories that have low nutrient density. The refinement of flour has been partially compensated for by adding iron, thiamin, riboflavin and nicotinic acid to constitute "enriched" flour. But — since there is no national requirement for flour enrichment, not all flour is enriched. In many cases, highly extracted non-enriched flour is being used by manufacturers of prepared and convenience foods.

The incidence of goiter in some regions of Texas appears to be associated with an inadequate intake of iodine. This is somewhat surprising, since it was presumed that goiter had virtually disappeared in the United States paralleling the introduction of iodized salt. Furthermore, in the absence of national requirements, both iodized and non-iodized salt are available on the grocery shelves. If the consumer selects non-iodized salt, his iodine intake is likely to be inadequate. Admittedly, iodized salt presents some technological difficulties to food processors, but they are not insurmountable. In areas such as Utah, where iodine deficiency goiter was once endemic, individuals should routinely purchase iodized rather than non-iodized salt.

Little effort has been made to insure high nutritional value in new plant varieties developed for use as food by man. Foods from plant sources are generally less expensive, but they also tend to be less well balanced relative to man's nutritional needs, than are those from animal sources. Corn is a notable example. Though an expensive source of calories, it is deficient in some of the essential amino acids. If these protein building blocks are obtained either through chemical synthesis in the body or by consumption of foods containing an excess of these nutritional elements, then corn becomes a useful food for man. In the case of corn, an alternate approach has proved workable. The skills of the nutritionist were combined with those of the plant breeder and corn varieties minus the nutrient deficits have been developed.

By contrast, in many cases, especially with fruits, researchers are de-
developing varieties to suit the requirements of mechanical processing while neglecting to assure either nutritional qualities or flavor. Thus, the nutrient composition of all foods must be continuously reviewed and the information publicized.

The concept of nutrient density, the ratio of nutrients to calories, is proposed as a way to facilitate this process.

HELPING THE CONSUMER COPE

In their most recent document (Recommended Dietary Allowances, 1968), the Food and Nutrition Board of the National Research Council has suggested appropriate intakes of individual nutrients for various segments of the population. These value judgments are based upon existing knowledge of nutritional science and obviously are subject to revision as new knowledge becomes available.

The “Recommended Dietary Allowances” (RDA) attempt to recognize that food requirements differ: among various age groups, for growth, for special physiological needs, and for each sex. For some nutrients, the recommendations are based upon relatively extensive analyses, while for others, the bases are now limited. Except for calories, the cited allowances are designed to afford a margin sufficiently above the average physiological requirement to cover normally encountered variations within a general population. The margin above normal physiological requirements that is provided by the allowances varies for each nutrient because of differences in body storage capacity, variations in the precision of assessing requirements, and the possible hazards of excessive intakes of certain nutrients.

The RDA provide a buffer against an increased need during common stress situations, and they permit full realization of growth and reproductive potentials. A temporary, emergency feeding of large groups under conditions of limited food supply and physical disaster would be more than adequate if it adhered to the RDA data. The RDA allowances, however, might not meet the abnormal requirements of persons depleted by disease, traumatic stresses, or prior dietary inadequacies.

“The primary objective of the recommended dietary allowance is to permit and encourage the development of food practices by the population of the United States that will allow for greatest dividends in health and in disease prevention.”

The recommended dietary allowances may be entirely too detailed to achieve the above-quoted primary objective of helping the general public and they do imply a degree of precision which is not justified. Food manufacturers and consumers evidence considerable confusion about how to apply the RDA information. When combined with tables of food composition, the allowances could provide guidelines for menu planning and meal preparation that would assure adequate intakes of nutrients for which requirements have been established. But if the public is to benefit from the concept of recommended dietary allowances, they must be simplified, publicized, and widely used.

RATIO OF NUTRITION TO CALORIES

Today’s consumer is constantly confronted by new convenience and prepackaged foods, and other results of advanced processing technology. In addition to confusing the average consumer, these changes in food commodities generate a need for continual re-evaluations of what constitutes an adequate nutrient intake. Even if he makes a substantial effort, the consumer finds it difficult to define the real contribution of specific foods to his dietary needs. Most often, the consumer has to rely on the labels, which rarely provide the necessary facts. People who need special foods to satisfy therapeutic requirements often have an even greater problem with labels. Labeling is, therefore, an important public issue.

Food promotion gimmicks tend to confuse rather than educate the consumer. A standard of reference must be devised that will be acceptable to the manufacturer and promoter of food, comprehensive to consumers, and simultaneously have credibility and currency with the scientific community.

When requirements for nutrients are expressed in terms of detailed recommended dietary allowances, they become cumbersome and complex for the consumer to interpret. The requirements of a particular individual for a particular nutrient is a difficult problem to define in meaningful terms. It seems most logical to build upon the concept of recommended dietary allowance, but with some simplification to meet educational and consumer goals. A possible solution is hereby proposed.

By relating the recommended dietary allowances to the caloric content of foods we can develop a more understandable and useful description of food. Each basic nutrient can be calculated as a proportion of the calories in a “normal” serving and the result referred to as nutrient density. In other words, assuming an individual requires 2,000 calories a day, those calories should contain 100 percent of each of the essential nutrients so far as their individual requirements are known.

The nutrient density system immediately recognizes the strength and limitations of the food with regard to its contribution to the daily nutrient requirement. Currently the label on one prepared food states, “1 oz. of this food provides these percentages of minimum daily adult requirements.” It is extremely difficult to translate this data into contributions to the daily nutrient needs.

If we assume that the food in question provided 100 percent of an individual’s allotted 2,000 calories, the question becomes: “What portion of the individual’s need for each nutrient does the food provide?” If the nutrients were defined as 'recommended
dietary allowance in proportion to calories the answer would be obvious. Admittedly, the nutrient to calorie ratio ignores subtle but important differences that concern the scientist. But it might facilitate food labeling that would help the consumer and also aid industry in promoting foods that benefit the consumer. If consumed in sufficient quantity, a food having a nutrient to calorie ratio (or a nutrient density) of 10 would indicate a potential dietary supplement for the nutrients cited. A food having a nutrient to calorie ratio of 0.1 would obviously be deficient in that nutrient.

In developing the nutrient density concept, we have obviously taken license with the recommended dietary allowances by assuming a standardized requirement. In view of the difficulties currently being encountered in trying to determine RDA's that will satisfy widely varying human needs, the liberty may be justified.

For those requiring special diets and for use by the average consumer, labels must be made more informative and comprehensive. The proposed modified and somewhat simplified application of the recommended dietary allowances could facilitate such a change. If one were to express the nutrient composition of each food per 2,000 calories, and then express each food's nutrient density as a proportion of the recommended dietary allowance, a practicable expression of food quality could result.

Charts A through E have been designed to show graphically the ratio of selected nutrients to calories in various foods. A nutrient to calorie ratio of one is considered ideal.

Chart A presents the nutrient densities for an important breakfast item, orange juice, which is graphically shown to be an excellent source of vitamin C. Further, in proportion to the calories that orange juice provides, it has surprisingly good nutrient density for protein, vitamin A, vitamin B1, calcium and iron. To consume enough orange juice to satisfy one's calorie need would be expensive, but the point for emphasis is that vitamin C is in 30-fold excess over calories.

Whole milk (Chart B) is an inexpensive and good source of nutrients. It is an excellent source of high quality protein, and vitamins A and B1. Much of vitamin B2 in the American diet comes from milk products. Part of vitamin C is lost in the pasteurization process.

One of the unsupplemented common breakfast cereals is detailed in Chart C. Cereal is an inexpensive source of calories but some cereals do not have a high nutrient density. When cereal is consumed with milk (cup of cereal and about one-half cup of milk are typical proportions) it is obviously a good food (Chart D). Due largely to the composition of milk, the combination has a good nutrient density with respect to protein, vitamin A, vitamin B1, vitamin B2 and
calcium. The vitamin C content is still inadequate because neither milk nor cereal provides adequate amounts of that vitamin. The complementary value of adding orange juice or fresh fruit to a breakfast of cereal and milk is readily apparent from the charts. Chart E illustrates the potential for chemical supplementation of cereal. A basic cereal made from one of the common grains, when supplemented with concentrated and chemically synthesized nutrients, is a food of good nutritional quality, even without milk. The cereal analyzed in Chart E has a high nutrient to calorie ratio in every respect except calcium, and obviously if it is consumed with milk this defect is corrected.

Carefully designed supplementation can thus substantially enhance the value of a food. But, as with most things, supplementation can be overdone. Even though for the most part our bodies can tolerate an excess of various nutrients, if the nutrients are in a large excess relative to calories, they can sometimes be a problem.

The nutrient to calorie ratio illustrated in these charts (and discussed in the text) would help the average consumer evaluate his actual intake vs. need for specific nutrients. Food manufacturers with particularly nutritious products could be expected to appreciate the advertising value of putting such information on their labels. We might thus begin to realize new benefits from already available nutritional information.

### POINTS TO REMEMBER

1. Malnutrition occurs in the United States among all income classes.
2. In U.S. health surveys, of those examined were anemic, had goiters, and/or were deficient in their intakes of common vitamins and protein.
3. Despite adequate diets, some individuals may be poorly nourished because of genetic defects.
4. Nutritional excesses can be as dangerous as deficiencies.
5. A principal cause of death among American men is cardiovascular disease.
   A person seeking a proper diet is best concerned with calorie counts rather than cholesterol intake.
6. Better diets in most developed countries during the last century have been a factor in
   - the average child reaching a physiological maturity 2½ years sooner, and
   - each successive generation being taller and heavier.
7. Food habits are to blame for many cases of malnutrition.
8. Recommended dietary allowances were developed to encourage correct food practices.
9. About 30 percent of the average diet consists of empty calories (calories with no nutritional benefit).
10. Consumers need to recognize and use the nutrient to calorie ratio (nutrition density) when choosing foods.
Utah State University scientists are trying to substitute facts for fables about elk herds. Surprisingly little is known about reproduction patterns and efficiency in elk, and, without such data, management often becomes mostly a matter of guesswork.

The USU research, designed to extend over 3 years, will answer some basic questions. It may even determine whether twinning could be made more common in elk as a way to increase a dwindling herd.

By using both captive and free-living elk, the scientists will be able to determine if holding animals in pens modifies their physiology and behavior. If it does, then results will have to be adjusted before being used on free-living herds. The researchers currently have 4 males and 22 females in their captive herd. And, despite the open winter last year, which hindered the trapping of free elk, they've started accumulating data.

Throughout the year, they have taken blood samples from both the cows and the bulls to check on hormone levels. The samples, plus observation during rutting season will help define the duration of breeding readiness in females, and when a female goes through her first breeding cycle. The scientists hope to also determine whether yearling and 2-year-old males are physiologically capable of breeding. If they are, perhaps greater harvests of older bulls could be allowed without restricting herd growth.

Some of the elk cows have been tested for their reactions to drugs that are also being used to up twin production in bovine cows and in ewes. Of course, even if the captive elk can bear and raise twins, further work will have to be done to see if problems associated with living in the wild make twinning impractical.

With the so-called Doppler machine and/or by palpation, pregnancy rates of free-living and penned cows will be compared. Subsequent cow-calf counts in August and September should provide an indication of the percent calf survival. Correlation of the data from captive and free animals may provide insights into causes of occasionally disastrous calf losses.

Cooperative work with Montana

Figure 1. USU scientists are trying to remove some of the guesswork from elk management by investigating reproductive efficiency and patterns. This elk herd is receiving supplemental winter feeding at the Hardware Ranch located in Blacksmith Fork Canyon in Cache County, Utah. (Photo by J. B. Low)
State University personnel is clarifying questions about lungworm problems.

By the time this 3-year project is terminated, we should have considerable reliable data about elk reproduction. But if it develops as most research does, it will also leave several problems needing still more investigation.

Figure 2. This portable chute can be taken into the "field" where elk are trapped. Blood samples are taken and later analyzed to determine hormone levels. (Photo by John Ratti)

Figure 3. Penned elk also can be tranquilized to facilitate examination, sampling and testing. (Photo by Thomas Follis)

**WILDLIFE NOTES**

The auerhahn, world's largest grouse, weighs up to 13 pounds and has a 5-foot wingspan.

• The female burrowing owl lays its eggs in the shape of a horseshoe, the clutch numbering from six to seven eggs.

• A record 16,309,072 visits were made in 1969 to the 326 national wildlife refuges in the United States.

• The average cottontail rabbit weighs from 2 to 3 pounds, measures about 13 inches in length, and has ears about 3 inches long.

• A mole can dig a tunnel 225 feet long in a single night.

• The winter coat of the white-tailed deer is so well insulated that the animal can sleep in snow all night without melting it.

• The whooping crane, North America's tallest bird, winters at the Aransas National Wildlife Refuge in Texas after spending the summer on Canadian nesting grounds near the Arctic Circle.

• The Piraiba, a man-eating catfish that grows to 500 pounds, inhabits South America's Amazon River.

• A baby brine shrimp has only one eye and one main set of legs, whereas the adult has two stalked compound eyes and 11 pairs of swimming legs.

• New animals discovered during the 20th Century include the African okapi, a relative of the giraffe; the kouprey, a wild ox in Cambodia; the Congo peacock, New Guinea crocodile, blind white salamander in Georgia, and a blind white crayfish in Florida.

SEPTEMBER 1970
Economics of feeding grain to cattle

Lynn H. Davis and Jay C. Andersen

An article published in the March 1970 issue of Utah Science* concluded: “It is not financially practical to feed 4 pounds of grain each day to cattle on lush pastures. One pound of grain can be profitably fed, however.” Such a general conclusion is difficult to justify on the basis of the information presented. The purpose of this article is to discuss some economic principles and to show their use in problems of feeding grain to cattle on pasture.

In the article referred to, a comparison was made between two groups of animals. One group was grazed on alfalfa and the other on alfalfa and grass pasture. On each kind of pasture, half of each group was fed 1 pound of grain; and half was fed 4 pounds of grain. Slight variations occurred in stocking rate and initial weight of the cattle, but presumably these variations did not affect the results. The difference in reported gains within each pasture type was assumed to be the result of the different levels of grain feeding. The weight gains and cost and receipt information for the alfalfa and grass pasture indicated a “net profit” per acre of $76.43 when 1 pound of grain per day was clearly a profitable activity compared to feeding 1 pound.

Other Comparisons

A similar comparison was made for animals grazed on alfalfa pastures. In this case, however, the per acre “net profit” amounted to $69.93 from feeding 4 pounds of grain per day on alfalfa pastures which was less than the $85.48 net profit for 1 pound of grain per day. Presumably this last comparison led the author to conclude it was not profitable to feed 4 pounds of grain to cattle on lush pasture.

Economists call this general kind of production problem an input-output relationship. The principles can be applied to a variety of problems on the use of inputs such as grain in feeding livestock or irrigation water and fertilizer in the production of crops. It is essential to recognize the importance of putting things together in proper proportions. The farmer who manages such that he applies the correct amount of water to crops or feeds the right amount of grain obtains high profits from his production enterprises.

In an experiment such as the pasture feeding trials where varying amounts of grain were fed to cattle on pasture, it is essential to distinguish two different production situations for the two kinds of pasture. For each case, the response as measured by pounds of gain due to the amount of grain fed should be identified.

Production Situations

Each treatment level is a different production situation. Without more trials, it is not possible to define precisely whether or not an optimum situation has been achieved. In the data presented for alfalfa pastures, there was an additional gain of 161 pounds for an additional cost of $55.80 which is not profitable at $25.00 per hundredweight for live cattle. It would be profitable, however, if the gain could be sold for $35.00 per hundredweight. This points out the inability to make a general conclusion which fits all situations. If the price of grains was less, it may also be profitable. Thus, the profitability of the situation is dependent not only on the physical input-output relationship, but also on the price of the product and the input cost per unit.

In order to draw a conclusion as to the proper level of grain to feed, information must be available to show the added gain for each additional unit of grain fed.

Feeding Margins Important

In the earlier article, a value of gain of $25.00 per hundredweight was assumed. People who buy and sell cattle understand that a negative margin usually accompanies the purchase of cattle in the spring for grazing of summer pastures and then sale in the fall. Market price data are such that it is difficult to follow an animal through from spring to fall. But an analysis of price data for the period 1951-69 suggests an average price drop of $3.40 per hundredweight for choice 500-pound steer calves bought in Ogden during April and May and sold in September or October of the same year as 700-800 pound choice feeder steers. Prices were higher in the fall than in the spring in only 2 years. In 1952, prices dropped more than $10.00 per hundredweight.

(Continued on page 83)

*Alfalfa pastures compare favorably with grass-legume pastures and other field crops in Utah," Clair R. Acord.
KINGSTON - A NEW LIMA BEAN VARIETY

LEONARD H. POLLARD AND ALVIN R. HAMSON

Kingston, a new lima bean has been developed to meet the needs of the canners and freezer in the Intermountain area for a heavy yielding variety with good quality. It is adapted to the production areas of Utah and Idaho as well as many other sections of the United States. This new variety consistently produced good yields even when temperatures soared during the blooming period.

The plants grow 15 to 18 inches high and spread out 18 to 20 inches. Thus, they are adapted to planting in rows 18 to 22 inches apart.

Kingston develops a heavy crown set as compared to Clarks Bush, another popular lima bean variety. The pods contain two to four medium plump, clear skinned beans per pod. When blanched, the beans have an excellent green color.

Extensive trials of this variety have been conducted at Farmington, Utah, and on the Birds Eye trial grounds at Nampa, Idaho (tables 1 and 2). In 1965, this high yielding variety produced 6,582 pounds per acre at Farmington and 6,783 pounds at Nampa. Field trials at several other locations have demonstrated Kingston’s superiority over other varieties usually grown in the area. Some growers have even reported yields greater than those noted above.

The Kingston variety originated as selection 2043 from a cross of Utah 16, an early selection with white cotyledons, and Clarks Bush with backcrosses to Clarks Bush. A large number of these backcrosses were tested at Farmington and later at Nampa. Although many other selections have appeared promising, this selection proved best on meeting the need for a heavy yielding, good quality canned or frozen green lima bean.

Table 1. Yield and percentage of various sieve grades of lima bean varieties grown at Farmington, Utah, 1965

<table>
<thead>
<tr>
<th>Selection or variety</th>
<th>Harvest date</th>
<th>Percent sinkers</th>
<th>Grades</th>
<th>Average Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingston</td>
<td>Aug 27</td>
<td>16</td>
<td>5.05</td>
<td>40.40 43.98 8.11 2.46 6600</td>
</tr>
<tr>
<td>Clarks Bush</td>
<td>Aug 27</td>
<td>30</td>
<td>23.76 48.42 21.27 4.42 2.13 4923</td>
<td></td>
</tr>
<tr>
<td>Kingston</td>
<td>Aug 30</td>
<td>18</td>
<td>20.17 57.64 16.77 3.83 1.59 6565</td>
<td></td>
</tr>
<tr>
<td>Clarks Bush</td>
<td>Aug 30</td>
<td>35</td>
<td>48.35 35.96 10.12 3.62 1.95 5356</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Yield of lima beans grown by the Birds Eye Company at Nampa Idaho, 1965

<table>
<thead>
<tr>
<th>Selection or variety</th>
<th>Harvest date</th>
<th>Percent sinkers</th>
<th>Yield</th>
<th>Selection</th>
<th>Harvest date</th>
<th>Percent sinkers</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingston</td>
<td>Sept. 1</td>
<td>3.2</td>
<td>6787</td>
<td>Kingston</td>
<td>Sept. 4</td>
<td>7.1</td>
<td>6778</td>
</tr>
<tr>
<td>Early Thorogreen</td>
<td>Aug. 31</td>
<td>11.7</td>
<td>5360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. The Kingston variety originated from a cross of Utah 16 and Clarks Bush. It develops a heavy crown set and yields well under high temperature conditions.
Farmers have a choice of taxes

The old adage that nothing is certain in this life but death and taxes still holds. Utah farmers, however, now have a choice relative to their land taxes. This choice was brought about by the legislative enactment of the Farmland Assessment Act of 1969. In general, the act makes it possible for owners of agricultural land which qualifies under the provisions of the law to have it assessed and taxed on the basis of its agricultural-use value. This is not an automatic thing, however. Owners of agricultural property must apply to have the county assessor value, assess and tax their property on this basis. Otherwise, the county assessor will continue to value, assess, and tax their property according to its current market value.

The purpose of this article is to discuss some aspects of taxing agricultural land which should be considered by the property owner before deciding to talk with the county assessor.

THREE TESTS

To qualify, land must pass certain tests: (1) It must have been devoted to agricultural use during each of the preceding 5 years; (2) it must contain not less than 5 contiguous acres exclusive of the house with its associated buildings; and (3) the gross sales of agricultural products from this acreage must have averaged at least $500 per year. Under the Act, agricultural use is defined very broadly and includes the raising of forage and sod crops, grains and feed crops, dairy animals, poultry, livestock, fur animals, trees, fruits of all kinds, vegetables, nursery and floral and ornamental stock, and cropland retirement under an agreement with the state or federal government.

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Where the market value exceeds agricultural use value, taxes in the beginning year will be less for agricultural land that is taxed according to the provisions of the Farmland Assessment Act, figure 1. As taxes to be paid in future years are projected, the slopes of the lines will depend on agricultural use value, market value, and the percent increase in land values. The market value of land, generally speaking, increases faster, because of inflation, than agricultural-use value. Because taxes are higher in the base year on land taxed at its market value, the slope of the line is steeper for taxes paid on market valued land.

The area between the two lines represents the reduction in taxes over time by taxing land for its agricultural use value. The savings, of course, are greater each year since the slope of the taxes paid on market value is steeper, and hence the difference between the two lines increases each year.

If agricultural land is sold for use outside of agriculture, a roll-back tax must be paid. This roll-back tax is calculated by taking the difference in the year sold and multiplying it either by the number of years the land has...
been under the Farmland Assessment Act or by five, whichever is smallest. The roll-back tax is calculated for the most recent 5 years if it has been taxed on the basis of its agricultural use value for more than 5 years. Figure 2 depicts the roll-back tax as the shaded area, assuming the land was sold for non-agricultural use in the fifth year.

A break-even point occurs when the shaded area representing the roll-back tax is equal to the area between the two lines labeled Z and Y. In figure 2, the shaded area is greater than the area between lines Z and Y. Thus, it is possible for total taxes to be more for land taxed for agricultural use, but then sold for sub-division or other non-agricultural use. But a tax saving accrues to the landowner if he keeps his land in agricultural use for 9 years, for example, as shown in figure 3.

The shaded area is smaller than the area between lines Z and Y. The following has occurred to make the difference:

After 5 years, the only increase to the amount of roll-back tax paid is the increase in Z minus the increase in Y times five, indicated by the cross-hatched area. To reiterate, when the shaded area is equal to the area between Z and Y, a break-even point has occurred; and the total taxes paid will be equal for either method of taxation. To sell before that point, with market value exceeding agricultural use value, the seller would pay more total taxes, with the land being taxed at its agricultural use value plus the roll-back tax, than the total taxes paid on market-valued land. Any time past that point, the seller would benefit financially by having had his land taxed for agricultural use; and the benefits would increase each year.

An understanding of the break-even point and its controlling factors will help determine which way to have the land taxed. Under conditions where market value exceed agricultural use value and inflation causes market value to increase fast-

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break-even point could occur before the fifth year, figure 4. This condition is not likely to occur, however, because higher prices for agricultural
land reflects either higher prices for agricultural products or speculation.

The conditions thus far have assumed moderate changes in land value caused by inflation. If run-away inflation should occur, it is conceivable that a break-even point might never occur. Under extreme inflationary conditions of market values, line Z would slope upward (curvilinear) so fast that increases in the roll-back tax would more than offset any tax savings in earlier years.

Other things such as value of land in the first year, assessment level, mill levy, and the difference between taxes paid on agricultural-valued land also have an effect on the break-even point.

To demonstrate the effects of these factors, market value estimates for different classes of land in Cache County for 1969 were obtained from the Cache County assessor. For agriculture land values on the different classes of land, estimates made by the Utah State Tax Commission were used. The 1969 mill levy for Cache County of 62.73 mills was used in calculating taxes. An assessment level of 20 percent was used. This assessment level is somewhat above the present level, but work is currently underway to have a uniform assessment level of 20 percent throughout Utah.

Taxes were calculated for Class I irrigated cropland for both taxation on market value and agricultural-use value for a 10-year period. The roll-back tax was also calculated for each year as if the land were no longer used for agricultural purposes. By comparing the difference between the amount of taxes payable based on market value or based on agricultural use value with the roll-back tax, it was possible to ascertain the time period when the break-even point occurred.

The initial calculations assumed market values for land to increase at a rate of 5 percent per year and agricultural-use values to increase 2 percent per year. Under the assumptions, it took between 6 and 7 years to reach the break-even point, figure 5. In other words, a land owner would have to keep the land in agricultural production and taxed under the provisions of the Farmland Assessment Act for 7 years before any net savings in taxes would be realized.

As the difference in inflation rates between market and agricultural value increases, it takes more years to reach the break-even point. When the market inflation was assumed to increase at 2 percent per year, the time required to reach a break-even point was increased to between 9 and 10 years. As the difference between the inflation rates is decreased by assuming agricultural use values increase at 4 percent per year and market values continue to inflate at 5 percent, the break-even point is changed from almost year 7 to year 6.

As the difference between market inflation and agricultural inflation increases, the difference in taxes paid each year increases; and since this difference determines the roll-back tax, it requires that the area between Z and Y be extended over a longer period of time to offset the increased roll-back tax.

Thus far, the effects of the difference in values and taxation in the base year have not been emphasized. Factors that influence taxation in the base year are: the mill levy, the assessment level, the market value of land, and the agricultural use value of land. If the inflationary rates of agricultural land and market value land are the same, the underlying factor in determining the break-even point is the ratio of agriculture-use value to market value. Since the mill levy and the assessment level are a constant applied equally to both the taxes on market-valued land and agricultural-use valued land, they have no effect on the break-even point. The area between lines Z and Y also increases by the constant as is the roll-back tax; and hence, there is no change in the roll-back tax. So, the only effect we have to consider is the ratio of the agricultural use value to market value; this will indeed influence the break-even point. As the ratio of agriculture-use value to market value of land decreases, the time required to reach the break-even point is decreased; but as the ratio of agriculture-use value to market value of land increases, the time is extended. The reason that this occurs is that when there is little difference between the initial values, the difference (saving) between Z and Y is very small; and it requires a longer time period to be equal to the roll-back tax.

Figure 5. Years required for attainment of break-even point for land taxes.
ENCOURAGING . . .

Chemical shearing field tests

Initial field tests indicate that defleecing sheep with the chemical cyclophosphamide (CPA) does not adversely affect the sheep, wool, or lambs, the United States Department of Agriculture reports.

CPA works by constricting the wool fiber at the point of formation. As the wool grows, the constriction comes to the surface of the skin where the fiber can be broken off. If the wool is removed 7 to 12 days after treatment with CPA, the sheep is left virtually hairless.

At Beltsville, MD., scientists of the USDA's Agricultural Research Service found that defleecing sheep chemically did not adversely affect the animals, even in cold weather, if they were protected. Sheep covered with blankets after shearing were allowed to roam freely in an open shed and corral. They were kept in the shed only during rain or predicted rain. Under these conditions, no ill effects from climate were observed.

Wool taken from these sheep had fewer short fibers and thus was of a slightly higher quality than conventionally shorn wool, says Dr. Mary E. Hourihan, ARS fiber technologist. Short fibers are the result of second cuts made during conventional shearing. Since chemically shorn wool comes off close to the skin, it also is longer than conventionally shorn wool.

Treating pregnant ewes with CPA had no effect on the ewe, wool, or lamb. Scientists found that pregnant ewes could be defleeced as easily as nonpregnant ewes and that wool on the lambs was normal.

If further tests prove successful, a new method of removing wool will become available to the sheep producer.

Use of cyclophosphamide is experimental and has not been approved by the Food and Drug Administration as a defleecing agent, however.

BEE STUDIES PLANNED

Ways to protect honey bees and other kinds of bees from pesticides will be studied under a cooperative agreement with the United States Department of Agriculture.

USDA's Agricultural Research Service will provide $24,000 under a cooperative agreement with the Utah Agricultural Experiment Station, Logan, for research on the effects of pesticides on bees. The Experiment Station will provide an additional $5,370 for the 3-year project. Dr. William A. Brindley, Station entomologist, will study insect enzymes and other natural chemical processes that may increase honey bee resistance to insecticides. Ways to identify resistance in individual bees for selection in developing resistant strains of the insects will also be determined. Bee toxicology studies will also be made with various insecticides and combinations of insecticides and other environmental pollutants. Dr. George E. Bohart, apiculturist at Logan, will represent ARS.

FARM TAX CHOICE

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Thus, the gain in weight should not be valued at the average price per hundredweight at sale time.

Another possible way to measure the value of gain is the cost of obtaining it in an alternative way. This would be the opportunity cost for the gain. The gain obtained by feeding grain to cattle on pasture should not be valued higher than the cost of the gain that can be obtained in alternative ways such as renting pasture, grazing rangeland or even dry lot feeding.

In summary, this article has demonstrated the need for physical response data that allows relating the added output to each increment of input. Appropriate prices and costs can then be used to compare the additional expenditure with the added income.

WILDLIFE NOTES

Of the few animal species that migrated from South to North America after a land bridge had connected the two continents, the porcupine has traveled the farthest north to Labrador and Alaska.

- The eyeless starfish "sees" with photosensitive spots located on the end of each of its arms.
- Dragonflies are among the fastest creatures on wings, capable of flying backward, forward, up and down at unbelievable speed.
- Condors weigh up to 20 pounds and have a wingspread of at least 9 feet when in flight.
- Grasshoppers have been seen 1,000 miles at sea.
- Horned discs that spread out on each side of the toes of ruffed grouse enable the birds to walk on snow.
- European hare, introduced to this country in 1893, average 9 pounds apiece whereas the cotton-tail weighs less than 2 pounds.
- Insect-eating birds have a special membrane on the retina of the eye to enable them to see the smallest of flying bugs as well as we can see a man walking.
- Whales often "hold their breath" for as long as 50 minutes. They, like all other mammals, however, can drown if they get water in their lungs.