Perspectives on Future Directions for Animal Growth Research and Lean Meat Production

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Introduction

The efficient production of highly palatable lean meat is a major goal of the livestock industry. Animal growth, as it relates to rate of gain, feed to gain ratios and composition of the animal or carcass, is a critical component of this goal. Research related to this goal has a long history and has been multidisciplinary. Examples of the long-standing concern about animal growth and composition include the discovery and role of nutrients, elucidation of nutrient requirements for maximum performance, the selection and improvement of livestock for growth and carcass traits, the discovery of hormones and some feed additives and the understanding of variables which determine carcass composition and grade. In addition, there have been numerous studies on the process of growth in relation to the pattern of bone, muscle and adipose accretion in animals. These kinds of considerations have become an integral part of some courses and extension programs, and as a result many of these principles have been adopted by producers to contribute to advances in livestock production efficiency.

In the last decade or so there have been major advances in scientific instrumentation and techniques. These advances provide a new opportunity for expanding our understanding of animal growth and perhaps controlling it in ways that previously were not possible. Thus, the remainder of this paper will be devoted to a brief discussion of types of research, some suggestions for future research efforts and some comments on the need for human and financial resources to address questions important to what can best be described as "growth biology" (Mersmann, 1982). This terminology is meant to include all of the biological systems of the animal that influence growth and composition characteristics of the animal. Thus, it is an umbrella-like term that encompasses the expertise from multidisciplinary inputs related to many tissues, organ systems and ultimately the whole animal.

Research Categories

Prior to discussing any area of research, it is ideal to define or categorize the kind of information that is available or needed. For purposes of this discussion, I have chosen to classify research related to animal growth into four categories and then provide a brief definition and example of each. The purposes of this classification are to remind us of where a given type of information fits into the total picture, and to assist in assessing what information is critical to future advances. The categories are as follows:

A. **Observational** — This research documents the effect of some variable on the animal's performance or carcass traits, but provides little or no evidence as to why this effect was observed. For example, at some weight one would find that loineye area reaches a maximum size. Thus, this kind of research documents the "effect" of a variable or treatment.

B. **Mechanistic** — Research in this category provides information that explains or contributes to the understanding of the mechanism(s) which cause a treatment effect. For example, one would expect to find that loineye area reaches a maximum when muscle cell number, elongation and diameter have reached a maximum. Further mechanistic research would elucidate what factors control muscle cell number, length and diameter. Thus, this kind of research documents "causes" induced by treatments that produce specific "effects."

C. **Developmental** — Research of this type that relates to animal growth is concerned with finding new ways of measuring, altering or controlling growth parameters or body composition. For example, if a decrease in muscle protein degradation is favorable to muscle accretion and a larger loineye area, then developmental research could be directed to finding a compound which decreases muscle protein degradation. Initially this might involve work with an in vitro screen, but then any positive compound would need to be tested in the target species where its metabolism and disappearance would be determined in relation to other effects and residue concerns. Thus, the ultimate goal of this research is to identify and develop a potentially new product or technology.

D. **Application** — This type of research is concerned with testing new products or technology for their effectiveness. For example, a compound resulting from developmental research efforts to increase loineye area or muscle growth through decreased protein degradation would need to be studied at

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different levels of administration under different field conditions. Thus, the ultimate goal is to determine if this compound can pass the numerous tests and become a useful and profitable product in the marketplace.

Research in the "observational" and "mechanistic" categories is usually published and is the foundation of our general understanding of growth biology. As such, this kind of research provides a pool of information that can either serve as guidelines for additional studies or provide new insights for "developmental" research. New commercial products related to animal growth are generally dependent upon this informational base. Most of the research support in universities and government laboratories for "observational" and "mechanistic" studies has been of a non-industrial nature. This is understandable because these categories of research are further removed and less directly related to the creation of new products. However, if information in the "observational" and "mechanistic" categories is lacking, then "developmental" research can be seriously restricted. I believe that this situation now exists for many areas in the "mechanistic" category relevant to growth biology, and this deficiency is hampering some "developmental" research efforts.

Research Needs

In considering why the area of growth biology is in need of additional "mechanistic" types of research, there are numerous factors that have contributed, but the most important factor involves people and funding resources to do the work. This will be discussed in a later section, but first I will provide a current example of such a need and propose some additional areas for research.

The development and application of recombinant DNA technology is a very significant event with regard to areas such as growth biology. This technology provides new opportunities for developing commercial products relevant to animal agriculture that previously were not possible. The current commercial interest in bovine growth hormone produced by recombinant DNA technology is an example of how a major new technology can change the degree of importance that is attached to "observational" and "mechanistic" types of research. For example, until the advent of recombinant DNA technology, the "mechanistic" types of research related to the growth of bone, muscle and adipose tissues were primarily of interest to scientists who were curious about the growth and function of these tissues even though it was very difficult to obtain funding for this kind of research. Now that recombinant bovine growth hormone (RBGH) is being tested in cattle, there is much more interest in the effect of RBGH on bone, muscle and adipose tissues and the mode of action of RBGH for any effects that are produced. However, the information pool with regard to the mode of action of growth hormone on these tissues is so limited that very few definitive answers can be given. Thus, we now have a situation where a hormone that is known to be a key factor for growth can be supplemented, but we know very little about the long-term effects or its real mode of action! This is an example of technology serving as the driving force for science (Gormory, 1983).

With this real example in mind, the following questions will serve to illustrate other deficiencies in our understanding of growth biology that could serve as a focus of research investigations. It seems reasonable to predict that definitive answers to these questions could serve as a basis for new "developmental" research efforts.

1. What mechanisms are responsive to genetic selection and result in the well documented differences in body form and composition of animals? Until these mechanisms are more clearly understood, our ability to fully utilize genetic engineering techniques will be limited. For example, it would be desirable if we could have beef cows of some minimal frame size to reduce maintenance costs, but postnatally increase the frame size of their offspring that are produced as market or meat animals.
2. What kinds of laboratory tests can be devised that would serve as appropriate in vitro assays for assessing growth potential? One of the problems in studying animal growth is that it is a long process with no notable, single events. In contrast, the reproductive process in animals has many detectable events, such as estrus, and this is probably a factor that has contributed to our generally greater understanding of the process of reproduction compared to growth. A successful in vitro assay is one that would be useful in assessing the growth potential of animals at an early age or in screening compounds for their effectiveness in improving one or more characteristics.
3. Are there new technologies that could be adapted for the determination of body composition in animals? The rapid and accurate determination of body or carcass composition is a problem that is a present limitation to production, marketing and research aspects of animal agriculture. Some of the needs and justification for improvements in this area have been discussed by Cross (1982) and Schafer (1982).
4. Are there natural growth factors and/or inhibitors which influence the growth of bone, muscle and adipose tissues which have not been identified? If so, where are they produced, how are they controlled and what is their mode of action? Reports by Urist et al. (1983) and Farley and Baylink (1982) with respect to bone are of special interest in this regard.
5. What are the factors that determine muscle and fat cell number and size? Can these variables be manipulated by hormones or new agents? How can we make use of tissue culture and other techniques for the in vitro study of these variables?
6. What is the extent of variation within a species for muscle protein and fatty acid turnover, as well as other energy-consuming mechanisms such as Na-K pumps and futile cycles? Does the variation in one or more of these variables relate in a significant manner to important production variables such as rate, efficiency and composition of growth? Can we find ways to alter any of these mechanisms that are important to production variables?
7. What is the role of cell receptors and their possible differences in contributing to economically important growth characteristics of livestock?

8. What are the factors that bring about muscle hypertrophy in strength-producing exercises and can these mechanisms be induced during the growth of meat animals? It is well documented that such exercise stimulates muscle protein accretion and it may be possible to stimulate this mechanism, once it is fully understood, without actually involving the animal in the exercise.
9. Are there ways that we can limit or manipulate birth weight of animals and yet not detrimentally change the post-natal growth and composition of animals? Since large birth weights are associated with more problems at parturition, this can be a serious problem for the producer and requires more understanding of what controls pre- and post-natal skeletal growth.
10. What can we learn from the study of livestock that have evolved under very different environmental conditions or have been selected for economically important traits that would contribute to explaining why they are different? There are many breeds or strains of livestock throughout the world that have evolved under very harsh conditions with regard to feed resources. What can we learn about the mechanisms within such animals that may have made them energetically more efficient, and can we apply this information to the improvement of other livestock?

These questions certainly do not represent a comprehensive listing of all the important questions that could be addressed in the area of growth biology, but are only intended to serve as some examples. Some of these questions have been discussed in greater detail by Mersmann (1982). Answers to questions such as these are not easy to obtain, involve expensive research, and require special expertise with much more access to financial support than has been available in the past for this kind of research.

Human and Financial Resources

The scientific understanding in any area results from an evolutionary process that involves the employment of an adequate number of appropriately trained scientists, the development and availability of equipment and techniques, and a level of funding that is adequate to address significant unanswered questions. If any of these components is deficient, progress in elucidating new information will be slow. During the last decade, progress in growth biology has been in keeping with the minimal human and financial resources devoted to this area, but progress has been hampered by all of the previously mentioned components. However, there are a variety of indications which suggest that the area of growth biology will receive more attention and be given higher priority than in the past. Some of these indications include new job descriptions which specify growth biology, high research priorities for growth biology developed for animal agriculture (Pond et al. 1980; Intersociety Research Committee, 1980) and expanded research efforts by university, government and industrial laboratories that focus on topics encompassed by growth biology. To meet these new opportunities, I believe that we need to work toward implementing the following considerations:

1. Universities that are interested in developing a growth biology program need to carefully assess the kinds of questions they want to pursue, and then determine if the necessary resources that are necessary to bring about a meaningful effort can be obtained. In the absence of such planning and implementation of some major efforts, there will continue to be a shortage of people who are well qualified to make significant contributions to the "mechanistic" kinds of research that are currently needed. It would also be desirable for some regional planning discussions to take place so that some coordination of efforts occurs. In addition, it would be ideal for growth biology programs at each location to involve an interdisciplinary team approach, because the needs in growth biology are complex and beyond the expertise of any single area or discipline present in departments of animal science.
2. Students who are trained for work in this area need to have a strong background in the basic sciences necessary to address research questions concerned primarily with "causes" rather than only the "effects." These students should be recruited from within the area of animal science as well as areas other than animal science. It also seems likely that some research positions should be filled by people with training other than from animal science, because this brings some needed interdisciplinary perspective to such a program.
3. A competitive grants program for this area would be very helpful in many ways. It would not only provide some necessary funding, but would serve to highlight the needs and attract other scientists to work on growth biology problems. Efforts to bring about access to competitive grants need to continue. It seems unlikely that there will be more than a few agricultural experiment stations with sufficient funds to provide major support for a significant effort in the area of growth biology.
4. There is a need for more communication between industrial and nonindustrial scientists in areas of joint interest. This may lead to some additional support for work that serves as a foundation for industrial research interests. This has occurred in some other areas and it seems that the time is right for more of this interaction in the area of growth biology. Presently, greater interaction would be desirable because of the need for training people and obtaining certain kinds of information. G. A. Keyworth (1983), who is the President's Science Advisor and Director of the White House Office of Science and Technology Policy, recently discussed the need for closer interaction among academic, government and industrial research scientists. His comments are certainly appropriate for the area of growth biology. He also provided some interesting insights on R&D funding and training of personnel which are pertinent to other topics in this paper.
5. Although I have no definitive information, discussions with a variety of people lead me to believe that university teaching programs need to give more at-

tention to teaching in the area of growth biology. When compared to reproduction and lactation, for example, there are apparently very few courses at either the undergraduate or graduate level which are entirely devoted to the subject of animal growth. This is probably undesirable because growth is a complex integrated process which needs to be emphasized and taught as one of the major outcomes of animal agriculture (Allen, 1983). Courses on animal growth also need to include "mechanistic" rather than just "observational" aspects so that what is known and unknown about the process of growth becomes evident, and can serve as a foundation for more in-depth understanding and for future research efforts.

Summary

The area of animal growth biology has gradually evolved from a number of aspects to be recognized as an interdisciplinary approach to provide additional understanding of animal growth and composition. New techniques have provided an opportunity for studying mechanisms that contribute to differences in growth characteristics and the potential for new products that may enhance the growth or efficiency of the animal. There is a major need for additional human and financial resources to carry out the research and teaching programs important to bringing about additional understanding of the growth of animals. It is anticipated that animal growth biology will be a major beneficiary of new techniques and knowledge resulting from this era of the "new biology." Likewise, advances in our understanding of growth biology should contribute to improvements in animal agriculture. However, the present limitations relate directly to a serious shortage of the necessary financial and human resources necessary to capitalize on the exciting opportunities that are available for research on growth of livestock species.

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