Celebration of 100 Years of “Nutrient Requirement” Publications

Donald C. Beitz
Iowa State University
National Research Council

• The NRC plays a major role in establishing nutrient requirements

• The NRC is a private, nonprofit organization established in 1916 to provide advice to the U.S. Federal Government on issues of science and industry

• The NRC is the working arm of the National Academy of Sciences
History of the National Research Council

1863  National Academy of Sciences
      Abraham Lincoln signed a charter that established the NAS to serve the nation by furthering science and technology

1916  National Research Council
      Woodrow Wilson asked NAS to provide government with broader scientific research services to assist in military preparedness of the country

1917  Animal Nutrition Subcommittee of Committee on Food and Nutrition

1919  Division of Biology and Agriculture formed

1919  Animal nutrition became part of Division of Biology and Agriculture

1928  Committee on Animal Nutrition established
Agriculture Committee Transitions to Board on Agriculture and Natural Resources

1917 Agriculture Committee
1918 Division of Agriculture, Forestry, Botany, and Fisheries
1919 Division of Biology and Agriculture
1944 Agriculture Board
1973 Board on Agriculture and Renewable Resources (BARR)
                   Board on Agriculture (BA)
                   Board on Agriculture and Natural Resources (BANR)
Hierarchy of Committee on Animal Nutrition

- National Academy of Sciences (NAS)
- National Academy of Engineering (NAE)
- Institute of Medicine (IOM)

- The National Academies
- National Research Council (NRC)
- Board on Agriculture and National Resources (BANR)
- Committee on Animal Nutrition (CAN)
- Subcommittee on Horse Nutrition

National Academy of Sciences, Engineering, and Medicine (NASEM)
National Research Council Horse Publication

• 1949 – Recommended Nutrient Allowances for Horses

• 1966 – Nutrient Requirements for Horses

• 1973 – Nutrient Requirements for Horses, 3rd Revised Edition

• 1978 – Nutrient Requirements for Horses, 4th Revised Edition

• 1989 – Nutrient Requirements for Horses, 5th Revised Edition
Early Goals of Committee on Animal Nutrition

- Meet Hoover’s goal of “A chicken in every pot”

- Provide leadership to agricultural committee by “defining animal nutrient needs and feed nutrient values to allow farmers improve cost-effectiveness of feeding regimes”

- Utilizes knowledge of essentiality of nutrients as they were determined

- Face challenges in animal agriculture because of Great Depression
First Reports of Subcommittee on Animal Nutrition

1921

• Cooperative Experiments upon Protein Requirements for the Growth of Cattle

• On Formulation of Methods of Experimentation in Animal Production

• The Determination of the Protein Requirements of Animals and of the Protein Values of Farm Feeds and Ration
Early Publications of Committee on Animal Nutrition

1942

1. The Fluorine Problem of Livestock Feeding
2. Iodine – Its Necessity and Stabilization
3. The Nutrition of Swine during the War Emergency
4. Nutrition and Reproduction of Farm Animals
5. Suggestions for Meeting the War-Time Poultry Feed Situation
6. War Emergency Plans for Raising Calves and Heifers
Early Publications of Committee on Animal Nutrition

1943
1. The Effect of Storage of Grains on Their Nutritive Value
2. Is Animal Protein an Essential Constituent of Swine and Poultry Rations
3. Suggestions for Meeting the Poultry Feed Situation during 1943
4. Use of Phosphorous-Containing Substitutes for Bone Meal in Livestock Feeding with Particular Reference to the Fluorine Hazard
First Nutrient Requirement of Species
Publications

1944
• Recommended Nutrient Allowances for Poultry
• Recommended Nutrient Allowances for Swine

1945
• Recommended Nutrient Allowances for Beef Cattle
• Recommended Nutrient Allowances for Dairy Cattle
• Recommended Nutrient Allowances for Sheep
(1953: Changed to Nutrient Requirements for .....}

The National Animal Nutrition Program
First Species-Focused Report
First Five Species Reports
Second Wave of Species Reports

- Nutrient Requirements for Dogs (Number VIII)
- Nutrient Requirements of Laboratory Animals (Number X)
- Nutrient Requirements of Cats (Number 13)
- Nutrient Requirements for Foxes and Minks (Number VII)
- Nutrient Requirements of Rabbits (Number 9)
- Nutrient Requirements of Trout, Salmon, and Catfish (Number 11)
Selected Current Species Reports
The Process of Developing a CAN Report

1. Establish need for report (by CAN, stakeholders)
2. Develop charge to subcommittee (by NRC, CAN)
3. Search for candidates for subcommittee membership (by CAN)
4. Appoint subcommittee members (by chair of NRC)
5. Examine evidence and hold face-to-face meetings (by subcommittee)
6. Provide oversight of subcommittee (by CAN, NRC)
7. Report on findings, conclusions, and recommendations (based on fact and rigorous analysis of refereed data)
8. Review of report (by experts)
Content of Nutrient Requirement Publications

1. Digestion, biochemistry, and physiology of nutrients
2. Welfare and environmental aspects of nutrients
3. Nutrient requirement tables
   • Stage of life, production, reproduction
4. Nutrient composition of feeds
5. Model evaluation and prediction equations
   1989 – Dairy (6\textsuperscript{th}); 2001 (7\textsuperscript{th})
   1989 – Horses (5\textsuperscript{th})
   1996 – Beef Cattle (7\textsuperscript{th}); 2016 (8\textsuperscript{th})
   1998 – Swine (10\textsuperscript{th}); 2012 (11\textsuperscript{th})
   2007 – Horses (6\textsuperscript{th})
Sponsors of CAN Publications

- National Research Council
- National Academy Press
- Users of publications
- Federal organizations – e.g., USDA, ARS, FDA, NIH
- Private organizations – e.g., AFIA, CFIA
- Pharmaceutical and feed companies
- Foundations
- Animal commodity groups
New Technologies Stimulated Need for Revised Publications

• Discovery of essential nutrients
• Fat-to-lean ratios of carcasses
• Demand for saturated fat in human diet
• Demand for low-fat foods
• Use of metabolic modifiers
• New feed processing technologies on nutrient bioavailability
• Development of models of animal productivity
## Advances in Nutrient Requirements of Swine

<table>
<thead>
<tr>
<th>Ed</th>
<th>Year</th>
<th>Nutrients</th>
<th>Nutrients with an Estimated Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1994</td>
<td>11</td>
<td>TDN, CP, Ca, P, K, carotene, vitamins A and D, thiamin, niacin, pantothenic acid, riboflavin, and pyridoxine</td>
</tr>
<tr>
<td>2</td>
<td>1950</td>
<td>14</td>
<td>Added Lys, Trp, Met, Cl; Deleted K and vitamin A</td>
</tr>
<tr>
<td>3</td>
<td>1953</td>
<td>27</td>
<td>Added choline, vitamin B_{12}, Cu, Fe, I, Mn, and the 7 other essential AA</td>
</tr>
<tr>
<td>4</td>
<td>1959</td>
<td>29</td>
<td>Added DE (calculated from TDN), vitamin A, Mg, and Zn</td>
</tr>
<tr>
<td>5</td>
<td>1964</td>
<td>30</td>
<td>Added Se</td>
</tr>
<tr>
<td>6</td>
<td>1968</td>
<td>30</td>
<td>Changed carotene to β-carotene</td>
</tr>
</tbody>
</table>
## Advances in Nutrient Requirements of Swine

<table>
<thead>
<tr>
<th>Ed</th>
<th>Year</th>
<th>Nutrients</th>
<th>Nutrients with an Estimated Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1973</td>
<td>31</td>
<td>Added DE (not calculated from TDN), ME, and vitamin E</td>
</tr>
<tr>
<td>8</td>
<td>1979</td>
<td>35</td>
<td>Added K, vitamin K, biotin, and folacin</td>
</tr>
<tr>
<td>9</td>
<td>1988</td>
<td>36</td>
<td>Added available P and linoleic acid; Changed niacin to available niacin</td>
</tr>
<tr>
<td>10</td>
<td>1998</td>
<td>36</td>
<td>Added true and apparent ileal digestible AA and Cr recognized as a required nutrient; Changed AA and energy requirements estimated with mathematical equations (model)</td>
</tr>
<tr>
<td>11</td>
<td>2012</td>
<td>36</td>
<td>Added an updated computer model</td>
</tr>
</tbody>
</table>

(10 pages in 1944 to 189 pages in 1998; references from 69 to 1,524)
Use of Reports of Committee of Animal Nutrition

• Stimulate future scientific investigations
• Educate next generation of students for industry and academics
• Serve as central component of outreach programs to improve care of research, farm, and companion animals
• Stimulate discussions of:
  • Sustainable animal agriculture
  • Food safety and quality
  • Animal care and well-being
  • Environmental quality
  • International trade and development
• Provide a principal reference on animal nutrition for academia, animal industry, consultants, and producers
### Foreign Translation Versions of Nutrient Requirement Series

<table>
<thead>
<tr>
<th>Language</th>
<th>Years and Species</th>
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<tbody>
<tr>
<td>Bulgarian</td>
<td>1998, Swine</td>
</tr>
<tr>
<td>Japanese</td>
<td>2001, Dairy Cattle</td>
</tr>
<tr>
<td>Korean</td>
<td>2007, Horses</td>
</tr>
<tr>
<td>Year</td>
<td>Animal Category</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2016</td>
<td>Beef Cattle</td>
</tr>
<tr>
<td>2012</td>
<td>Swine</td>
</tr>
<tr>
<td>2011</td>
<td>Fish and Shrimp</td>
</tr>
<tr>
<td>2007</td>
<td>Small Ruminants, Sheep, Goats, Cervids, and New World Camelids</td>
</tr>
<tr>
<td>2007</td>
<td>Horses</td>
</tr>
<tr>
<td>2006</td>
<td>Dogs and Cats (2&lt;sup&gt;nd&lt;/sup&gt; being considered)</td>
</tr>
<tr>
<td>2001</td>
<td>Dairy Cattle (8&lt;sup&gt;th&lt;/sup&gt; underway)</td>
</tr>
<tr>
<td>1995</td>
<td>Laboratory Animals</td>
</tr>
<tr>
<td>1994</td>
<td>Poultry (10&lt;sup&gt;th&lt;/sup&gt; underway)</td>
</tr>
<tr>
<td>1992</td>
<td>Mink and Foxes</td>
</tr>
<tr>
<td>1978</td>
<td>Nonhuman Primates</td>
</tr>
<tr>
<td>1977</td>
<td>Rabbits</td>
</tr>
</tbody>
</table>
Contributors to Poultry Update

AB Vista
Adisseo
ADM
Ajinomoto
Cargill
Dupont
DSM
Evonik
Hy-Line
Huvepharma
Micronutrients
Novus
USDA-Ag Research Service

United Soybean Board
PA Poultry Research Committee
NRSP/NANP (Experiment Station Directors)
National Academy of Sciences (internal from reports sales)
IFEEDEER
Illinois Corn Marketing Assoc. (Cost of study $480K)
Recent Issue-Oriented Reports

- Safety of Dietary Supplements for Horses, Dogs, and Cats (2008)
- Mineral Tolerance of Animals (2nd revised edition; 2005)
- Air Emissions from Animal Feeding Operations
- The Role of Chromium in Animal Nutrition (1997)
- Metabolic Modifiers: Effects on Nutrient Requirements of Food-Producing Animals (1994)
- Vitamin Tolerance of Animals (1987)
- Ruminant Nitrogen Usage (1985)
- Selenium in Nutrition (1983)
- Underutilized Resources as Animal Feedstuffs (1983)
- Nutritional Energetics of Domestic Animals (1981)
- Taurine Requirement of the Cat (1981)
- The Effect of Genetic Variance on Nutritional Requirements of Animals (1975)
National Academy Press

• Non-profit publishing entity of NASEM

• Publisher of CAN reports

• Income from sales kept by Press

• In 2004, business model change where some income used for future publications of Nutrient Requirement series
### Summary of U.S. Sales of Nutrient Requirement Publications

<table>
<thead>
<tr>
<th>Title</th>
<th>Year Issued</th>
<th>Lifetime Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral Tolerance of Animals, Second Revised Edition</td>
<td>2005</td>
<td>1,398</td>
</tr>
<tr>
<td>Nutrient Requirements of Dogs and Cats</td>
<td>2006</td>
<td>3,796</td>
</tr>
<tr>
<td>Nutrient Requirements of Beef Cattle: Eighth Revised Edition</td>
<td>2016</td>
<td>2,261</td>
</tr>
<tr>
<td>Nutrient Requirements of Swine: Eleventh Revised Edition</td>
<td>2012</td>
<td>2,424</td>
</tr>
<tr>
<td>Nutrient Requirements of Fish and Shrimp</td>
<td>2011</td>
<td>1,899</td>
</tr>
<tr>
<td>Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids</td>
<td>2007</td>
<td>2,919</td>
</tr>
<tr>
<td>Nutrient Requirements of Poultry: Ninth Revised Edition</td>
<td>1994</td>
<td>9,965</td>
</tr>
<tr>
<td>Nutrient Requirements of Dairy Cattle: Seventh Revised Edition</td>
<td>2001</td>
<td>12,396</td>
</tr>
<tr>
<td>Nutrient Requirements of Beef Cattle,: Seventh Revised Edition</td>
<td>1996</td>
<td>11,569</td>
</tr>
<tr>
<td>Nutrient Requirements of Swine: Tenth Revised Edition</td>
<td>1998</td>
<td>8,340</td>
</tr>
</tbody>
</table>
Chairs of Committee on Animal Nutrition

J. P. Fontenot 1979-1981

(139 total CAN members – 1928-1998; 10 to 15 scientists per CAN)
Members of the Last Committee on Animal Nutrition

Gary L. Cromwell (chair) -- Univ. of Kentucky  Swine
Rosalina Angelo -- Univ. of Maryland  Poultry
Jesse Goff -- USDA/NADC  Dairy
Ronald Hardy -- Univ. of Idaho  Fish
Kristen Johnson -- Washington State Univ.  Beef
Brian McBride -- Univ. of Guelph  Ruminant
Keith Rinehart -- Perdue Farms, Inc.  Poultry
L. Lee Southern -- Louisiana State Univ.  Swine
Donald R. Topliff -- West Texas A&M Univ.  Equine
Transition of Committee on Animal Nutrition

- BANR conducted review of status of CAN in 1998-2000

- Review committee recommended transfer of activities of CAN to BANR

- More animal scientists were added to BANR

- Final outcome: Activities of CAN has been assumed by BANR

- NANP established and complements BANR
Role of NANP in Nutrient Requirement Series

- Complement NRC/BANR roles
- Help with fundraising (e.g., Poultry)
- Suggest authors of publications
- Recommend reviewers
- Provide high quality feed composition data
- Develop and provide animal models
Roles of Feed Composition Subcommittee

- Bring together data and research resources in the area of feed composition
- Foster communication among those collecting feed composition information
- Facilitate efficiencies and consistencies in data collection and maintenance
Roles of Modeling Subcommittee

• Improve use of predictive technologies and tools to best utilize available platforms

• To work with researchers to effectively share, combine, manage, manipulate, and analyze models and modeling information
Accomplishments and Current Activities of Feed Composition Subcommittee of NANP

1. Developed database structure for feed composition repositories with input templates for beef, dairy, poultry, and swine
2. Work with Modeling Subcommittee to support needs regarding ingredient composition data as model inputs
3. Continue to collect feed composition information
4. Identify assays or methods that prove to have potential benefits to diet formulation
5. Help different NRC/NASEM committees to develop feed composition tables
6. Create a webpage displaying feed composition tables
7. Develop algorithms to classify feeds automatically based on differences in nutrient composition
8. Organize symposium and participate in conferences
Accomplishments and Current Activities of Modeling Subcommittee of NANP

1. Update NRC Dairy Cattle Model 2001
   Two calculation errors were corrected
   Installation program was recompiled to support 64-bit Windows installations

2. Update NRC Beef Cattle Model 2000
   Created an installation program for model to operate on modern Windows-based computers

3. Work with researchers to develop and share modeling information
4. Develop a review of techniques used to evaluate models
5. Develop article with guidelines for reporting dietary information in publications
6. Evaluate software platforms that could be used across NRC models
7. Develop a database for observational data, for use in model development
8. Collect feedback from model users
9. Assess supply and requirement model subcomponents for use across species
Concluding Statements

1. Great foresight of Abraham Lincoln in promoting a national science program

2. Great contribution of CAN to the science, practice, and teaching of animal nutrition

3. Contributions made by hundreds of volunteer scientists as innovators, writers, reviewers, and users of CAN publications

4. Great example of public/private partnership in providing latest animal nutrition information to academic community, regulators, feed industry, producers, consultants, and other users

5. Publications regarded as the benchmark for animal nutrition