Pork Quality: Current and Future Needs of Industry and Academia

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Basic and Applied Research

Louis Pasteur "fruits of the same tree"

- Outline:
  - Pork Quality - Brief History & Current Status
  - Pork Quality - The Plausible Solutions (Quantitative & Molecular Genetics)
  - Pork Quality – "Food Chain" Practical Solutions

- Outline:
  - Pork Quality - Brief History & Current Status

- *PSE: Identification & Description (1950s)*
  - Degenerative/myopathic condition
  - Early post-mortem changes
  - Ludvigsen, 1954; Henry et al., 1955; Briskey et al., 1959
  - Briskey, 1964: 88 pages/225 literature citation

- *Post-mortem Changes (1962-1966)*
  - pH decline (review by Briskey at al., 1966)
  - PSE association with glycolytic rate
  - Certain pigs were predisposed to rapid post-mortem glycolysis

- *Relationship of pH & Temperature (1961)*
  - PSE = pH and temperature relationship (Wismer-Pedersen & Briskey, 1961)
  - Importance of chilling (color & WHC)

Overview of Issues in PSE/RSE Meat Quality: Current Problems and Future Directions Packer Costs Associated with Quality Problems

Packer Defect	Cost $/Head	Cost Controlled by Farmer Percent	Cost Controlled by Farmer $/Head[1]
Leanness problems:			
Backfat thickness	2.80	100	2.80
Degree of ham and butt trimming	1.87	100	1.87
Excessive seam fat	.63	100	.63
Bellies too fat or too thin	.14	100	.14
Weight problems	.88	100	.88
Carcass problems:			
Carcass condemnations	1.00	75	.75
Abscesses	.47	100	.47
Bruises	.08	75	.06
Skin problems	.01	75	.0075
Arthritis	.08	100	.08
Other	1.29	0	0
PSE/color problems:			
Color	.27	75	.20
Pale, soft, watery	.34	75	.25
Dark, firm, dry	.01	75	.0075
Total packer costs	10.08		8.15

[1] Calculated by multiplying cost per head and percent of cost controlled by farmer.
Source: National Pork Producers Council, 1994
Vertical Coordination in the Pork and Broiler Industries, Economic Research Service/USDA, April 1999

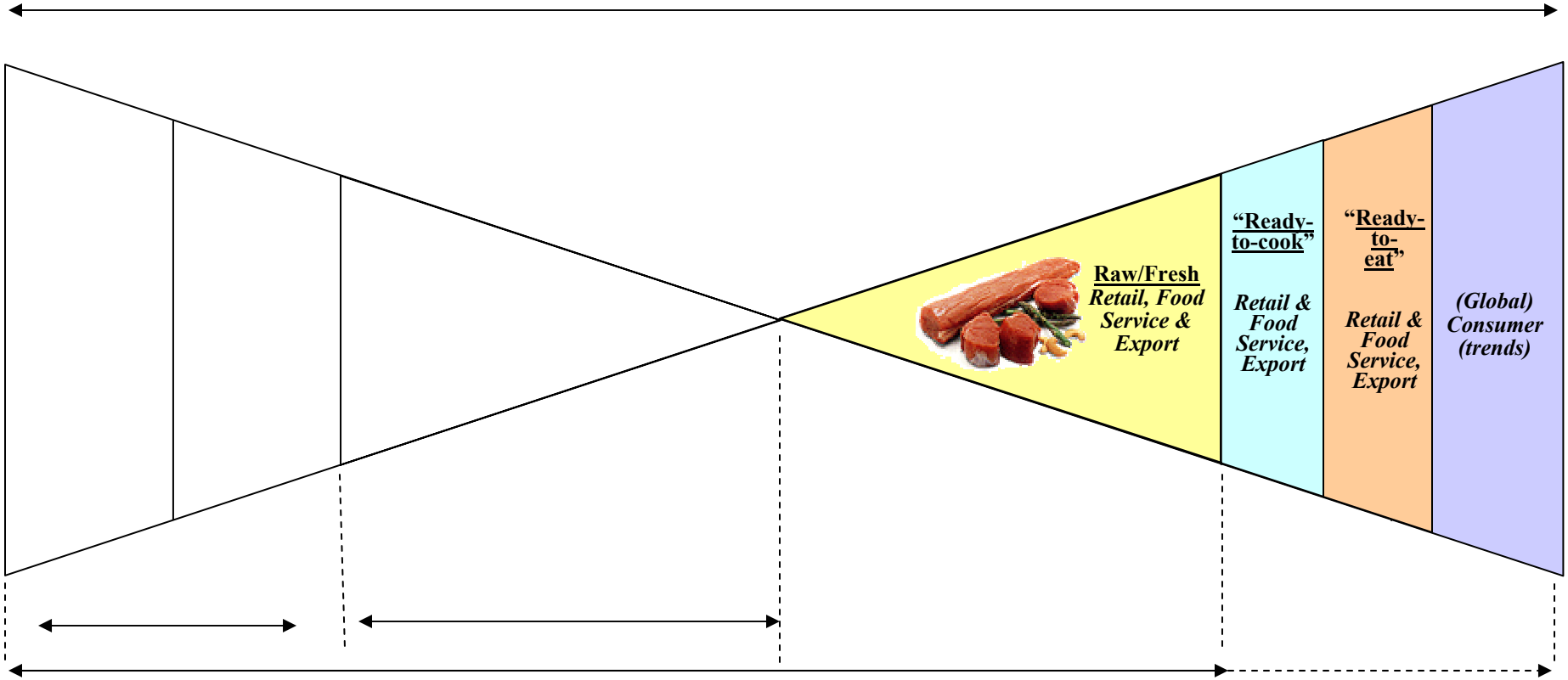
- *Surveys of Incidence (1960s -1990s)*

  - **1963**: 18% hams were PSE (daily range: 0%-to-70%; Forrest et al., 1963)
  - **1992**: 16% loins were PSE (Pork supply in the U.S.A.; Kauffman et al., 1992)
  - **1996**: 9.8% loins were PSE (Survey of U.S. Commerical Plants; Scheller et al., 1996)
    - RFN (Minolta L* < 50, pHu > 5.5): 68.6% to 66.5%
    - RSE (Minolta L* < 50, pHu < 5.5): 18.6% to 21.5%
    - PSE (Minolta L* > 50): 9.8%
    - DFD (pHu > 6.2): 0.5% to 1.1%

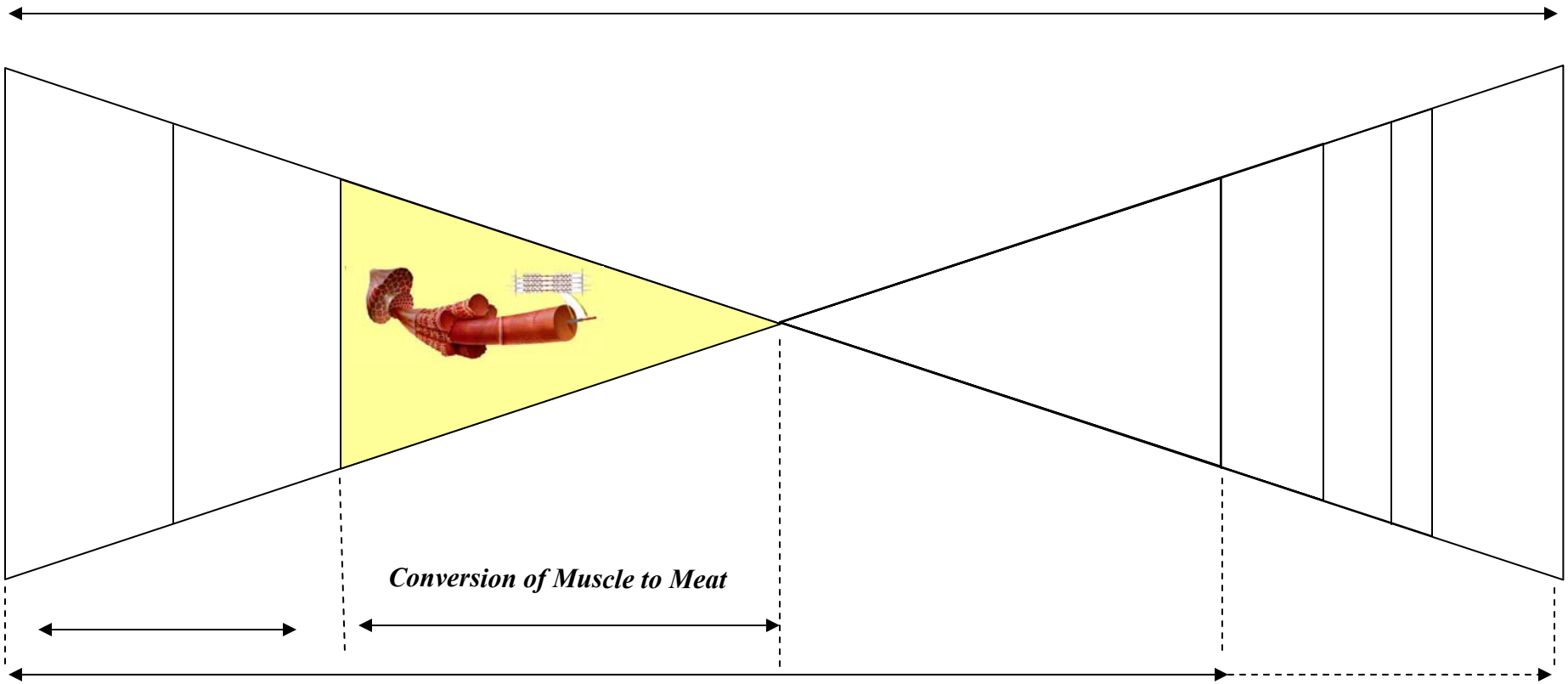
Incidence of PSE is decreasing, but…

- Current Pork Quality Challenges…
  - PSE - still persists, but at lower incidence
  - RSE – emerged and still considered as a meat quality problem (whole muscle firmness)
  - Variation/uniformity
  - Mechanisms of drip loss – not fully understood
  - Ultimate pH/Relationship to "eating quality" – within and between muscles
  - pH decline/Relationship to "eating quality" – within and between muscles

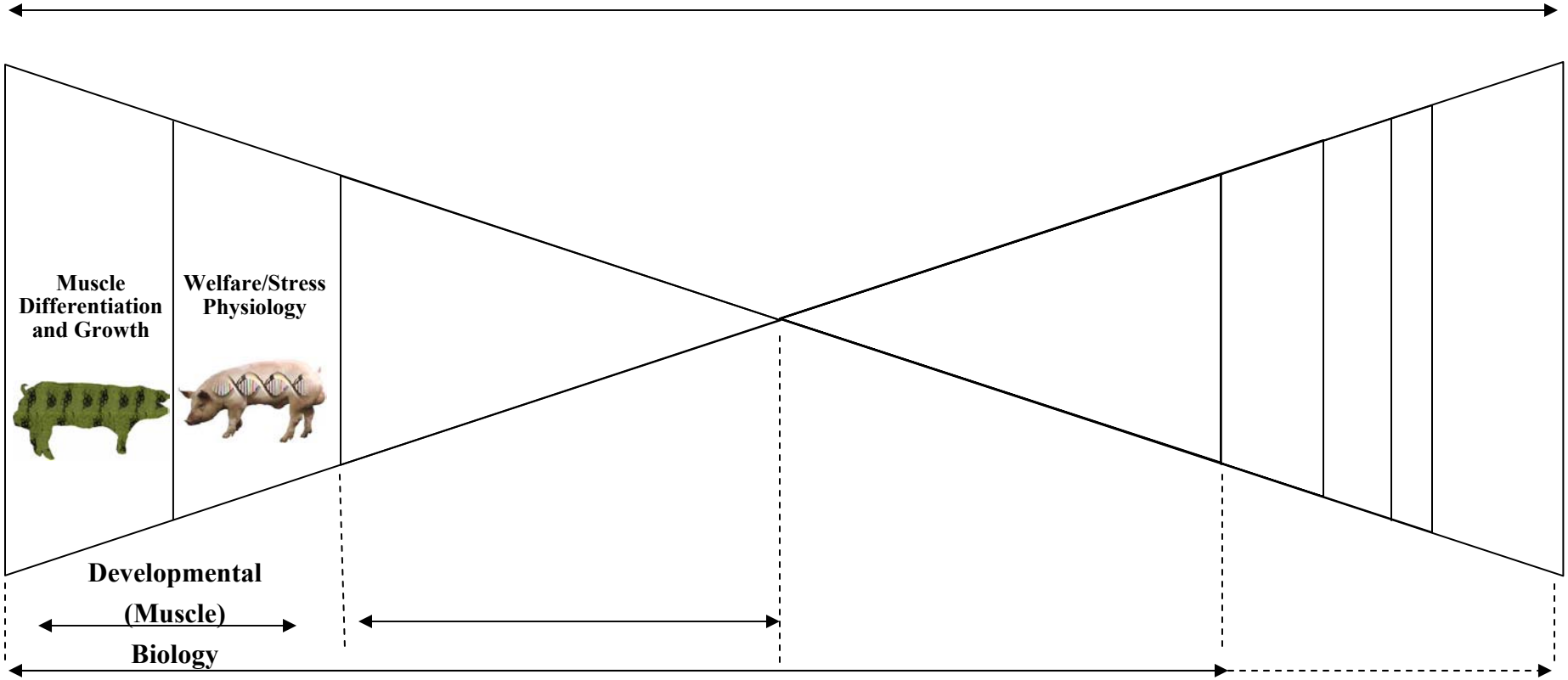
Muscle Foods System



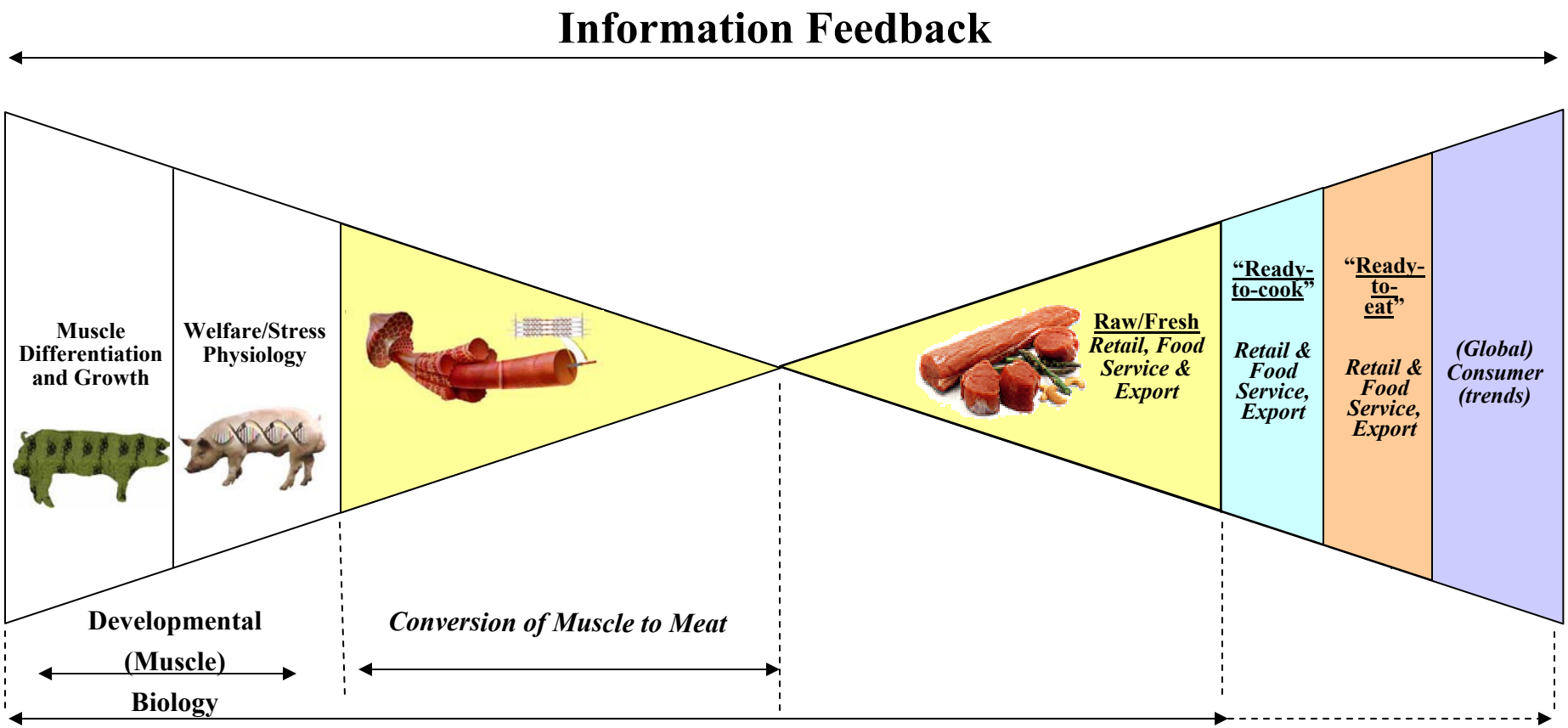
Muscle Foods System



Muscle Foods System



Muscle Foods System

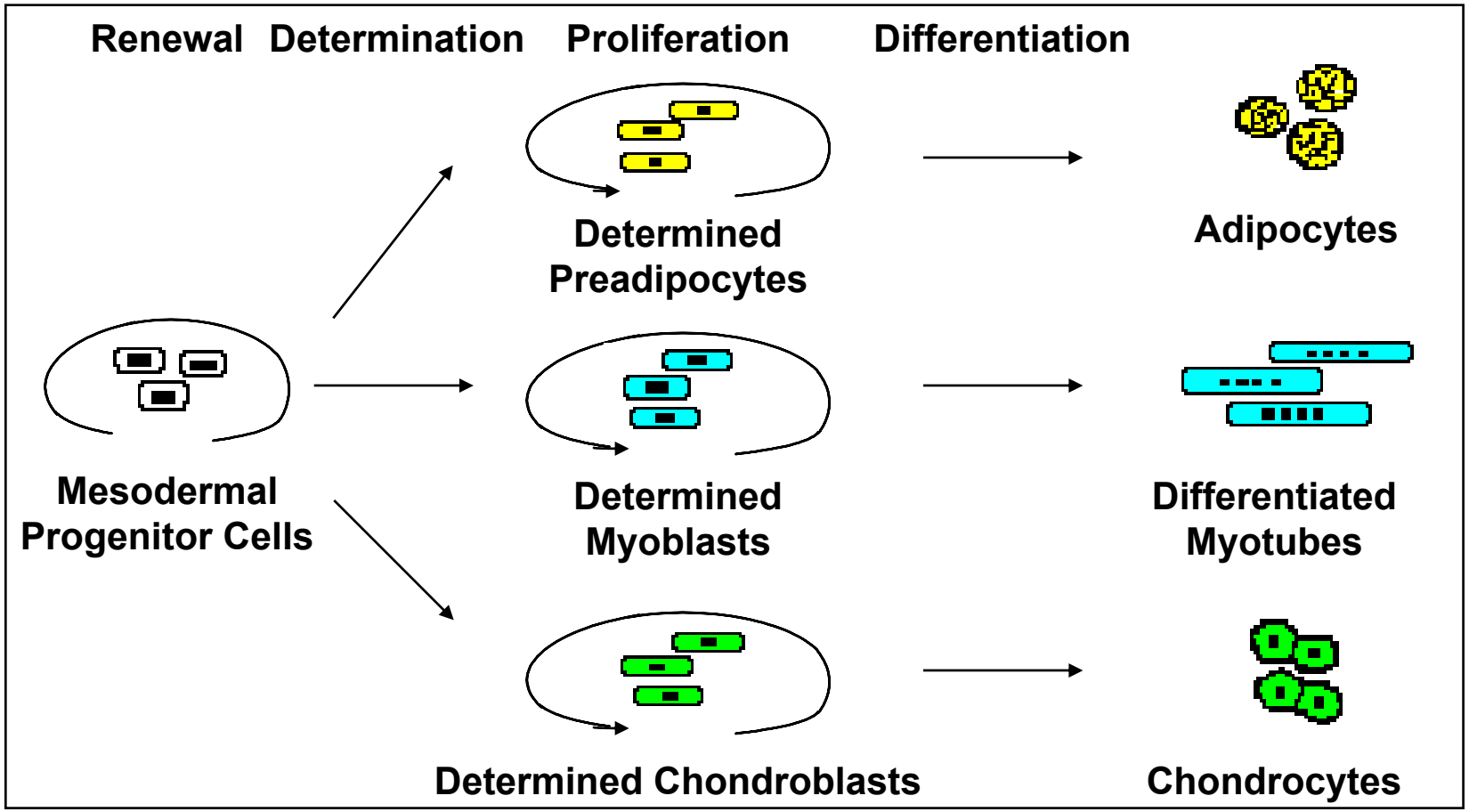


Functional Genomics & Proteomics

Muscle Foods

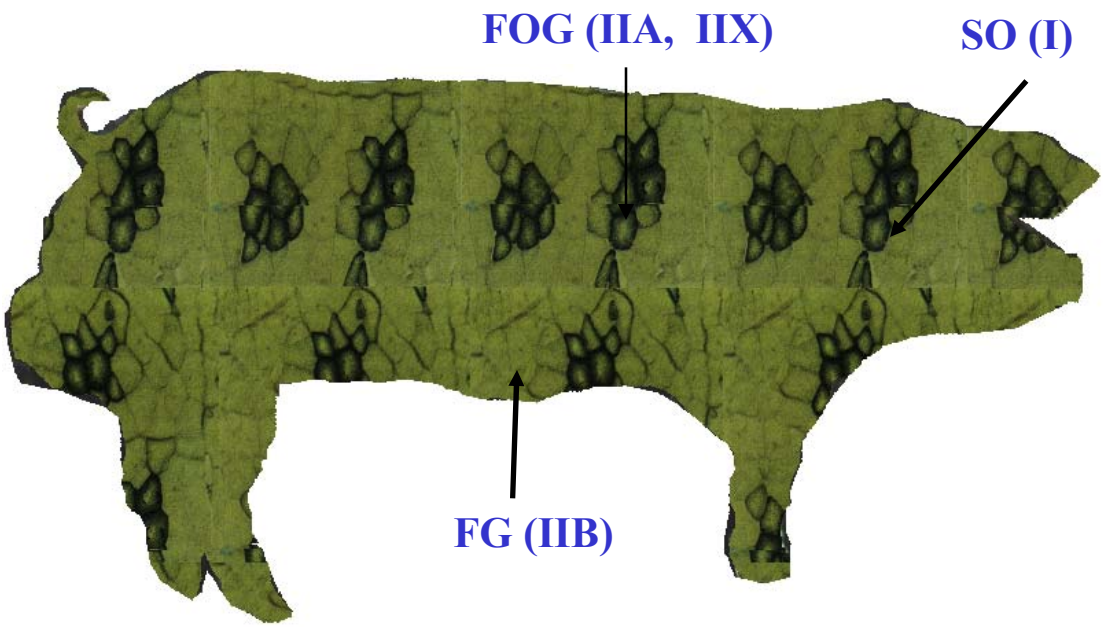
Developmental Biology

Steps Involved in Determination of Lineage and Differentiation to Cell Types



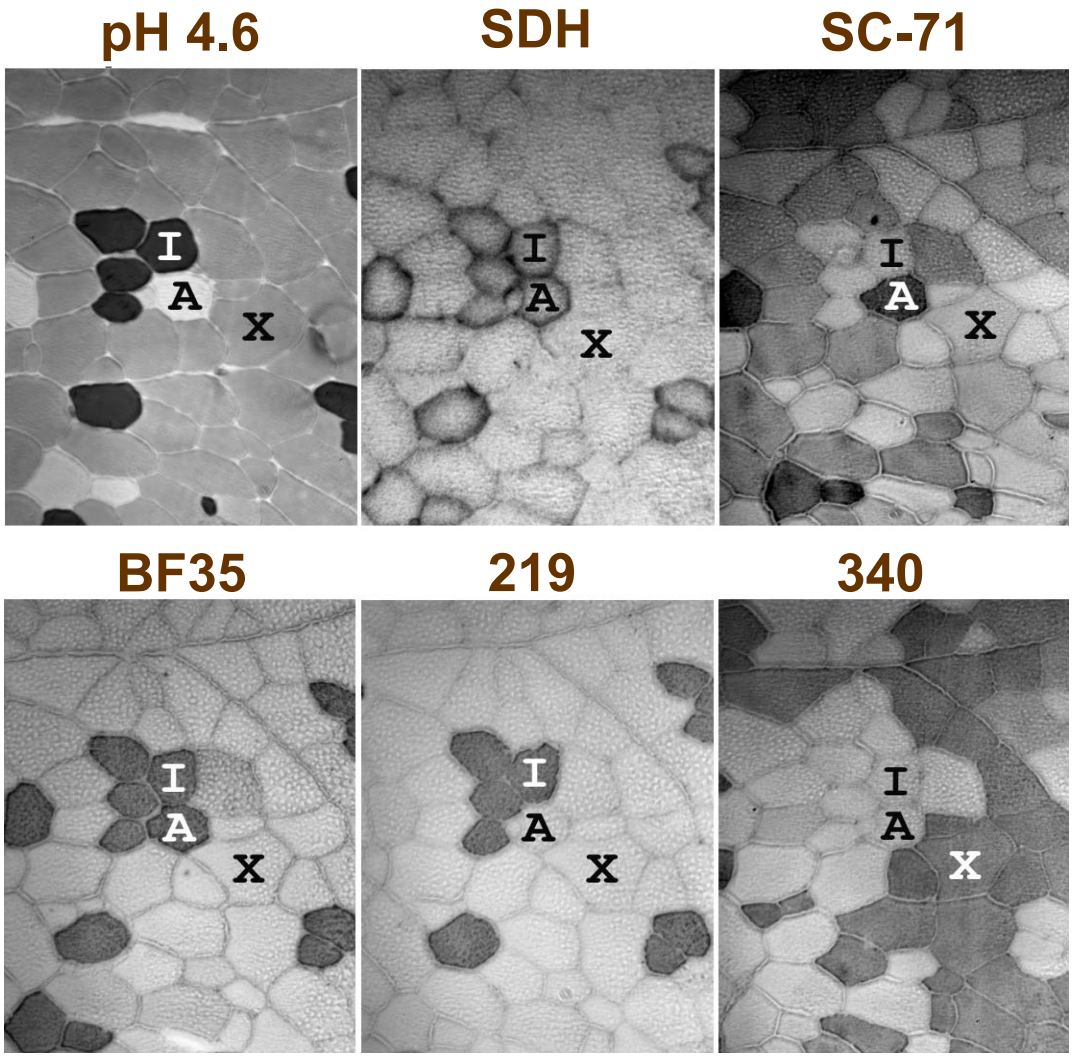
Duprey and Lesens, 1994

Muscle Fiber Types



- MHC-Type I = SO (slow contracting, oxidative, "red")
- MHC-Type IIa & **IIx =FOG** (fast contracting, oxidative, glycolytic, "white")
- MHC-Type IIB = FG (fast contracting, glycolytic, "white")

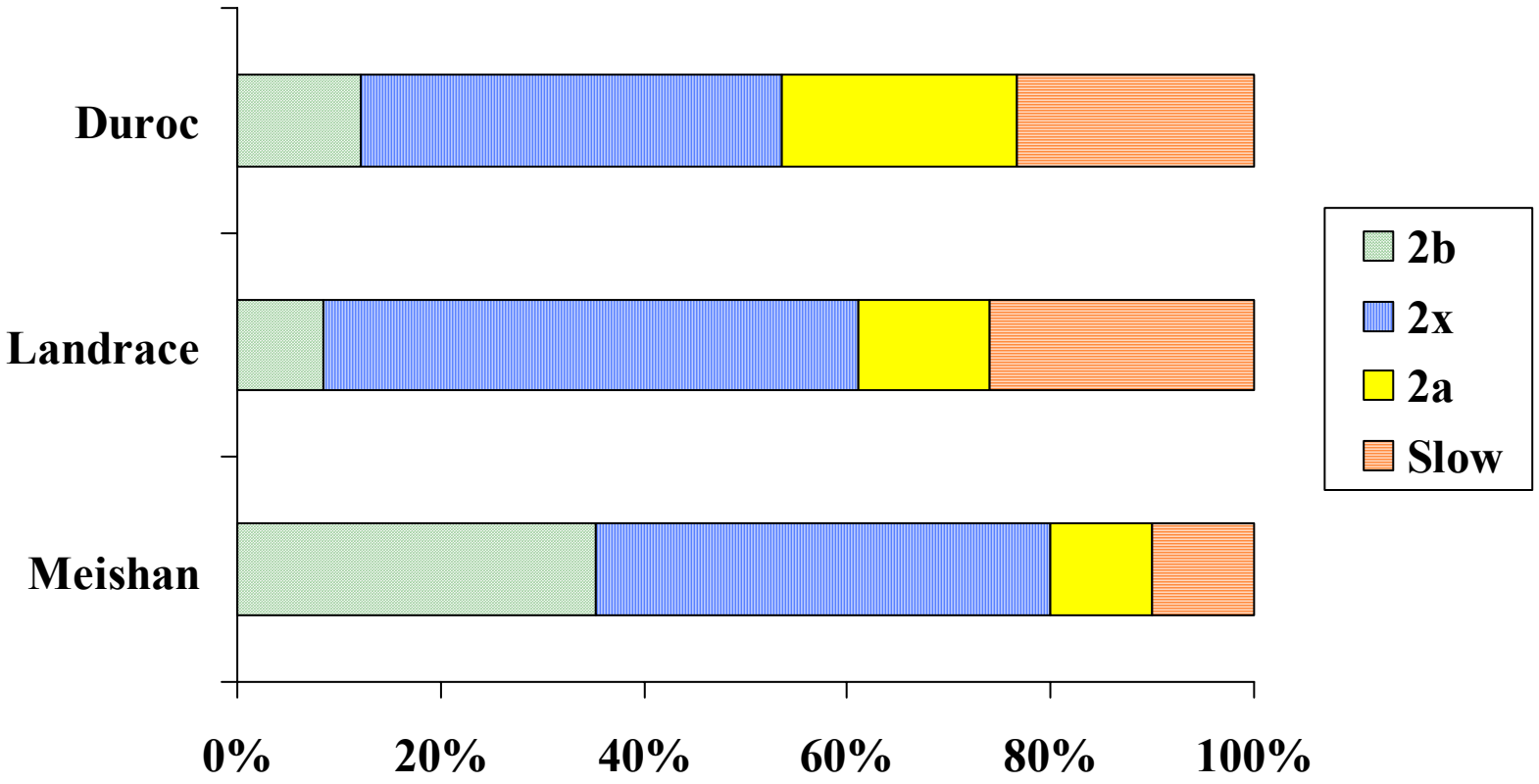
Distribution Patterns of MHC in Porcine Muscle



Greaser et al, ICoMST, 2000

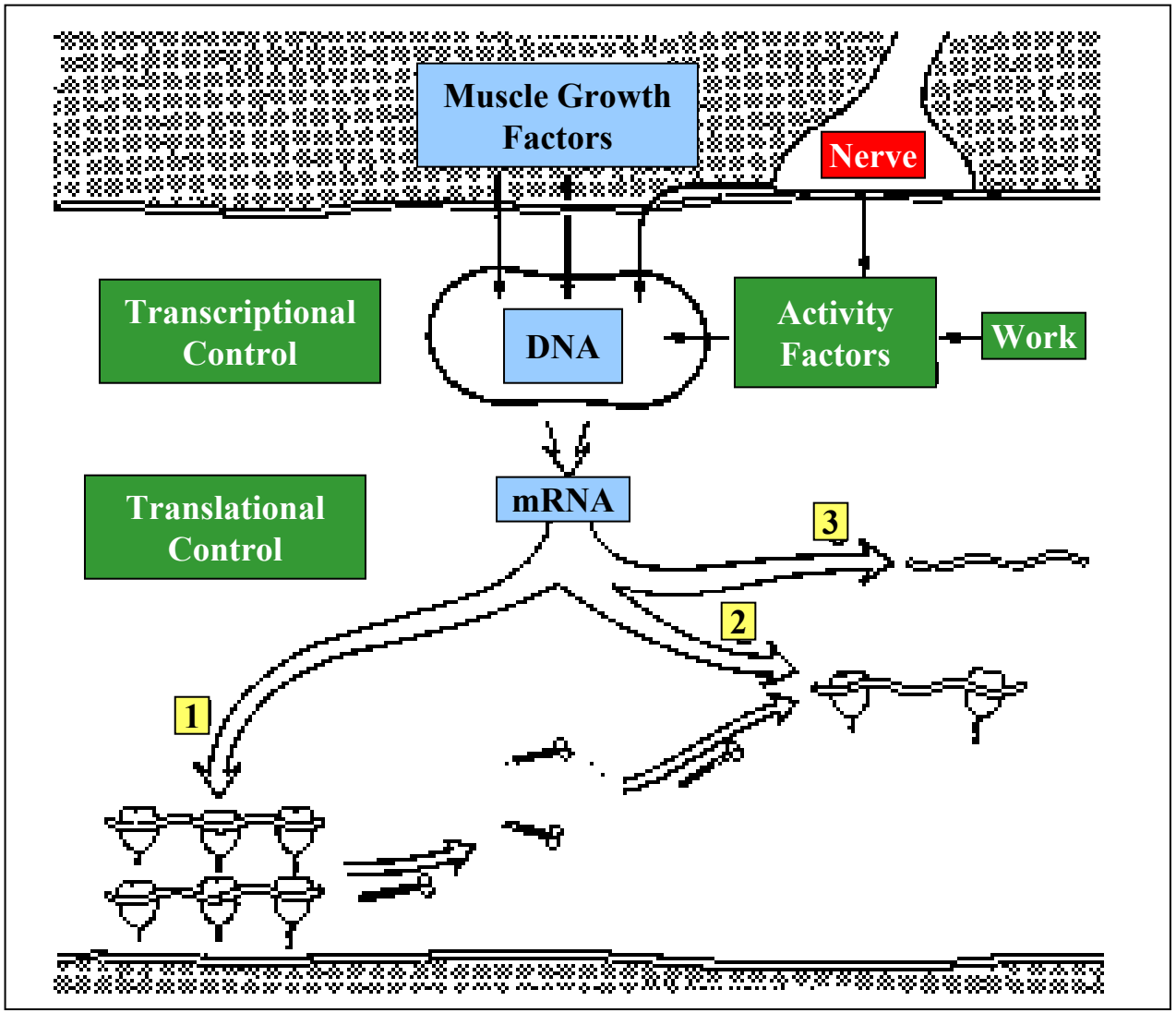
Differences in MyosinHC Isoform Proportion of Porcine M. Longissimus Thoracis

RT-PCR of RNA



Tonebe et al, 1999

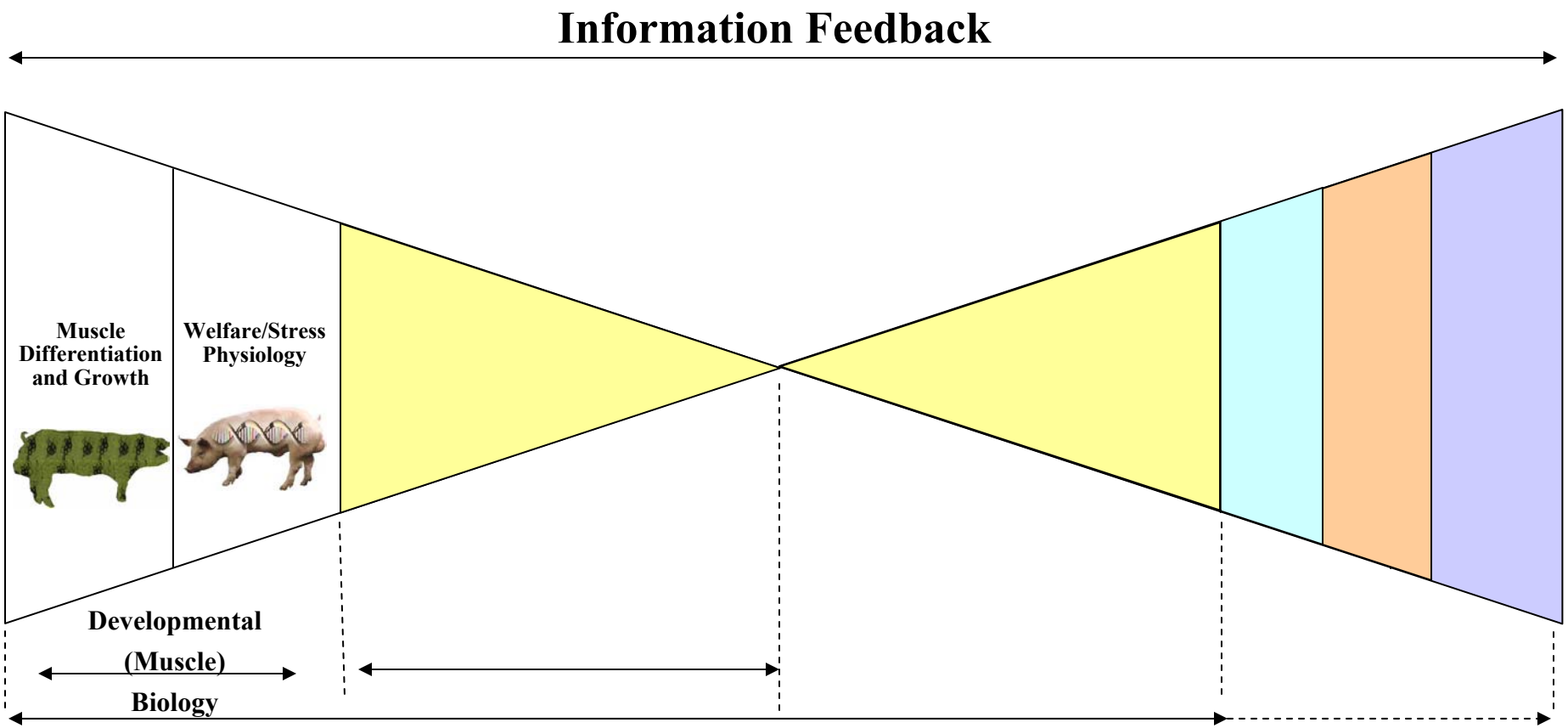
Transcriptional and Translational Regulation of Myosin Expression in Skeletal Muscle



Developmental (Muscle) Biology

- Understand protein deposition (MHCs) in fast growing pigs and its implication for meat quality
- Elucidate the role of satellite cell proliferation in muscle growth and meat quality
- "Optimize" collagen type and structure of porcine muscle in relation to physiological age and function (endomysium and perimysium)
- Muscle and liver glycogen storage mechanisms and their interaction

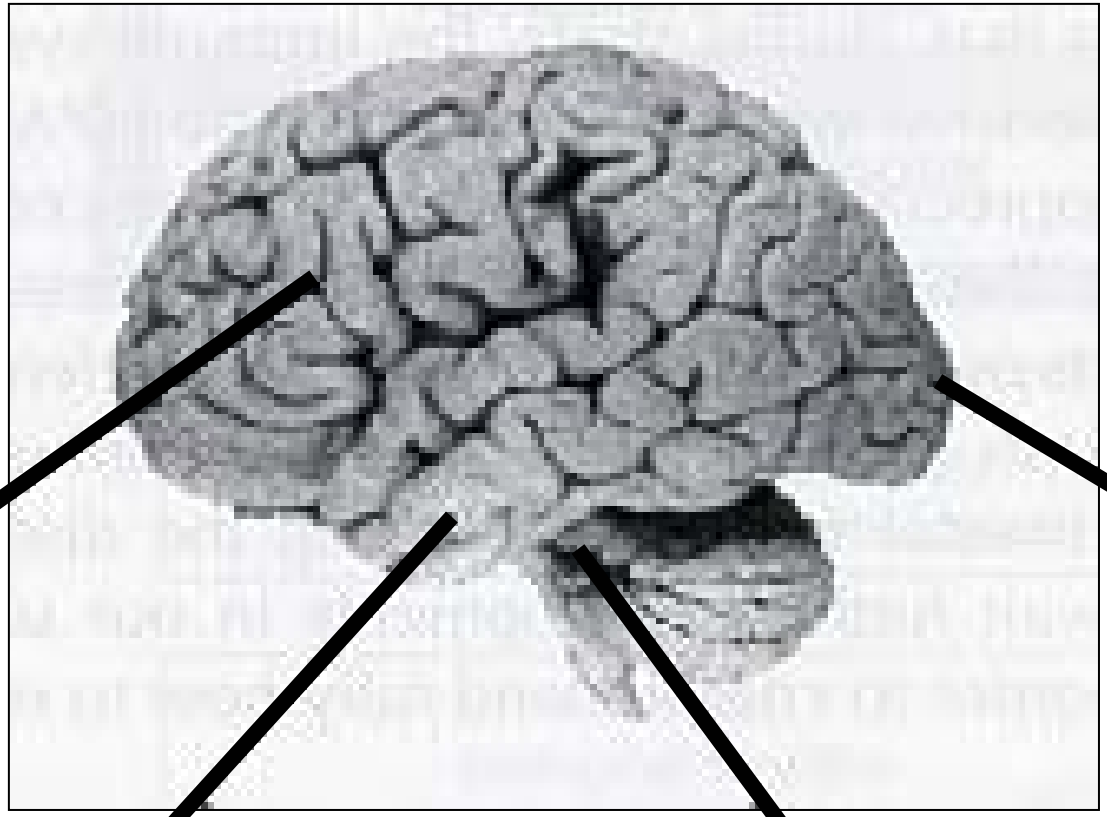
Muscle Foods System



Muscle Foods

General types of biological responses available to cope with stress

STRESS



Behavior

Immune system

Neuroendocrine system

Autonomic nervous system

Why reduce stress responsiveness?

- **Increased production (better ADG and FC)**
- **Improved reproductive performance**
- **Increased disease resistance**
- ***Better meat quality***
- **Improvement of animal welfare**

Stress Hormones and Meat Quality

(urine-based research)

	AD	NA	pH24	Lean%	IMF%
Cortisol	.42 ****	.15 *	.04	-.24 ****	.02
Adrenaline (AD)		.55 ****	.27 ****	-.29 ****	.07
Noradrenaline (NA)			.24 ****	-.07	-.07

F2 Duroc x Large White (n=312)

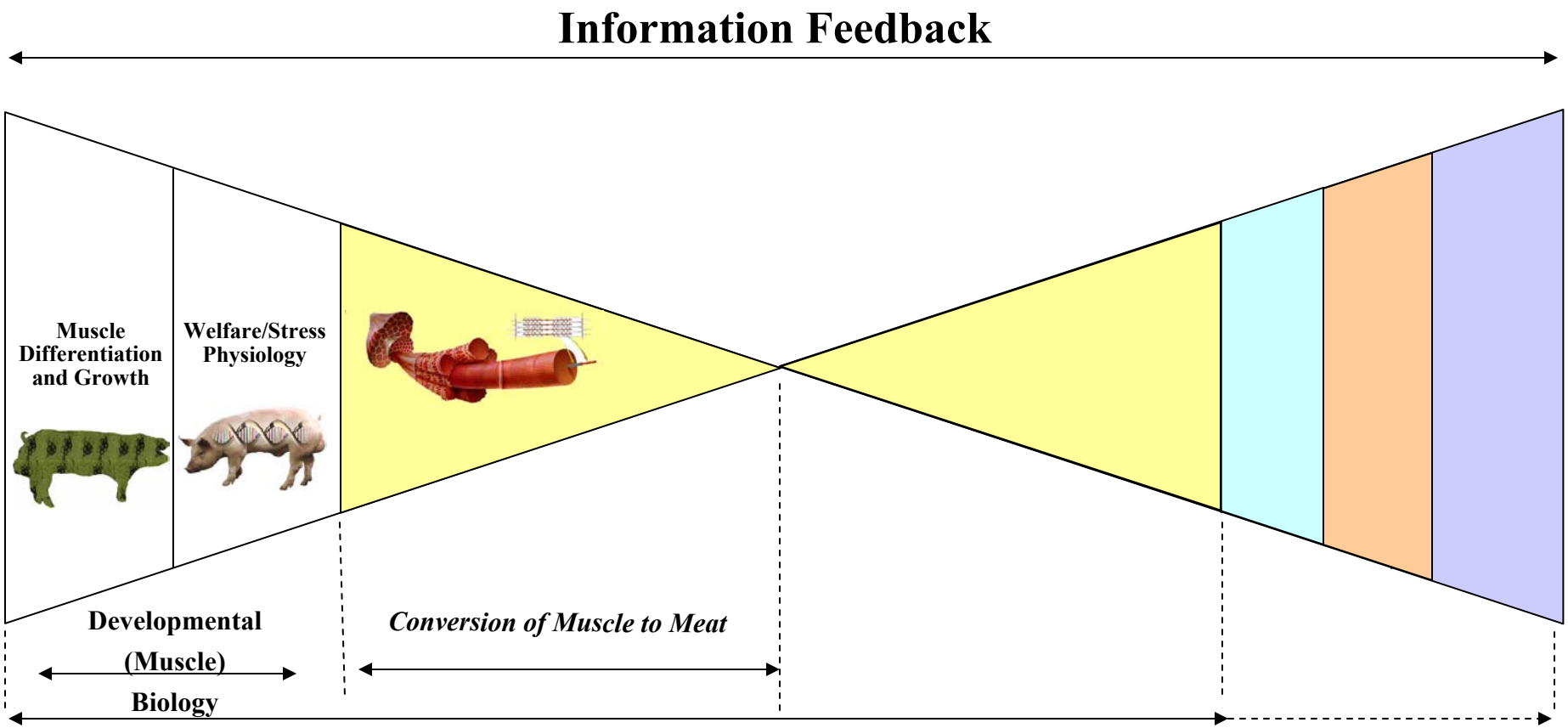
**** Significance

Foury and Mormede, 2002

Welfare/Stress Physiology R&E

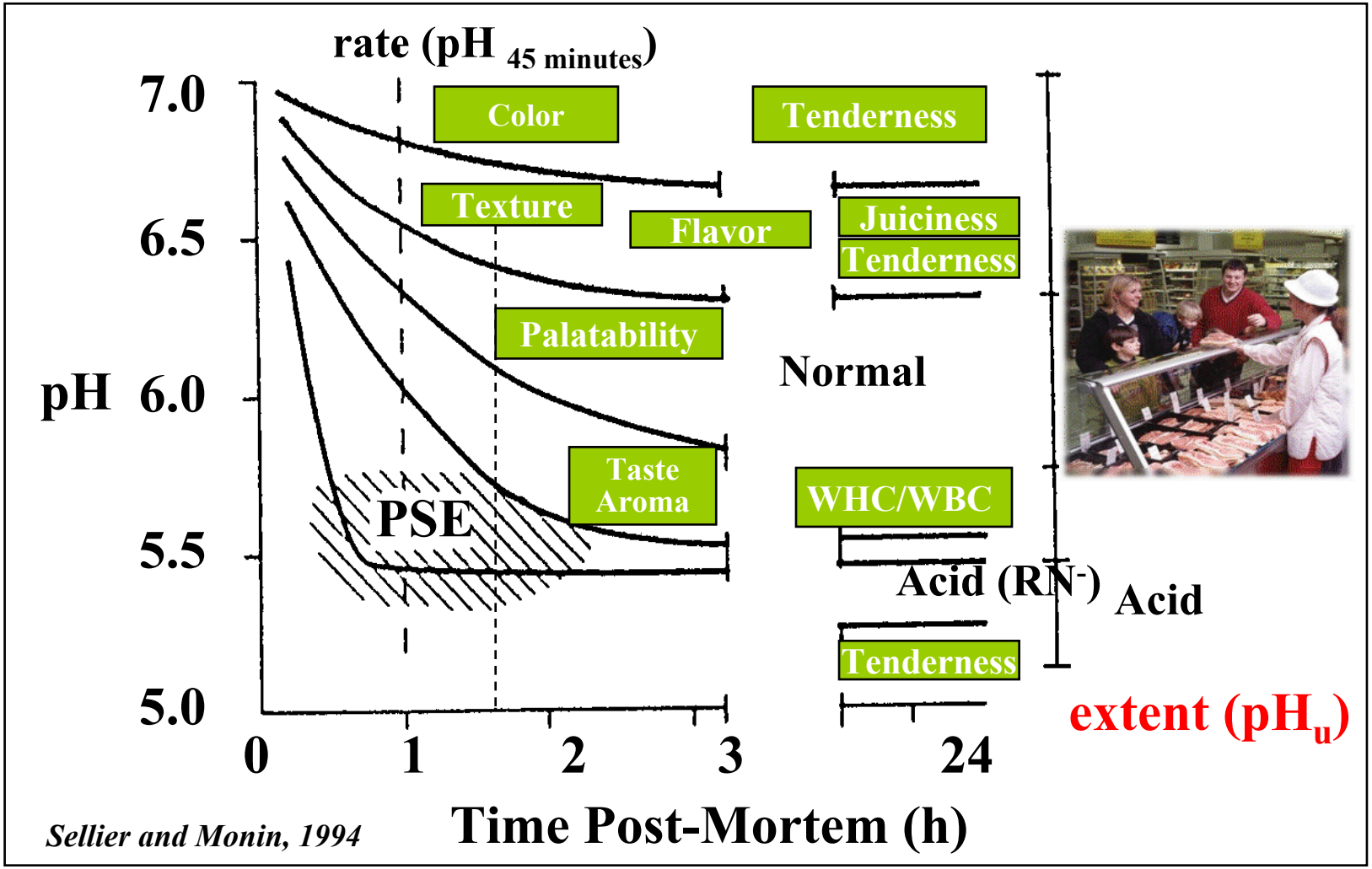
- Understand "Biological Cost of Stress" (i.e, stress vs. distress)
- Develop methods to measure distress under commercial conditions (farm-to-processing facility);
- Develop "Selective Breeding" to modify stress responsiveness of pigs
- Quantify" the effects of human-animal interactions on animal welfare/stress/productivity

Muscle Foods System



Muscle Foods

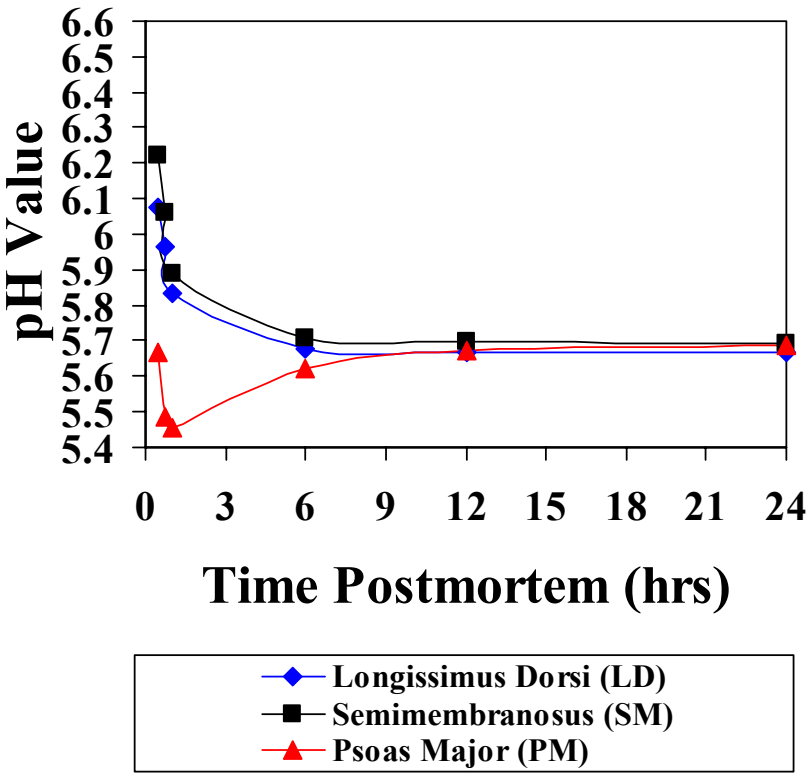
Relationship Between Rate of Post-Mortem pH Decline and Meat Quality in Pigs



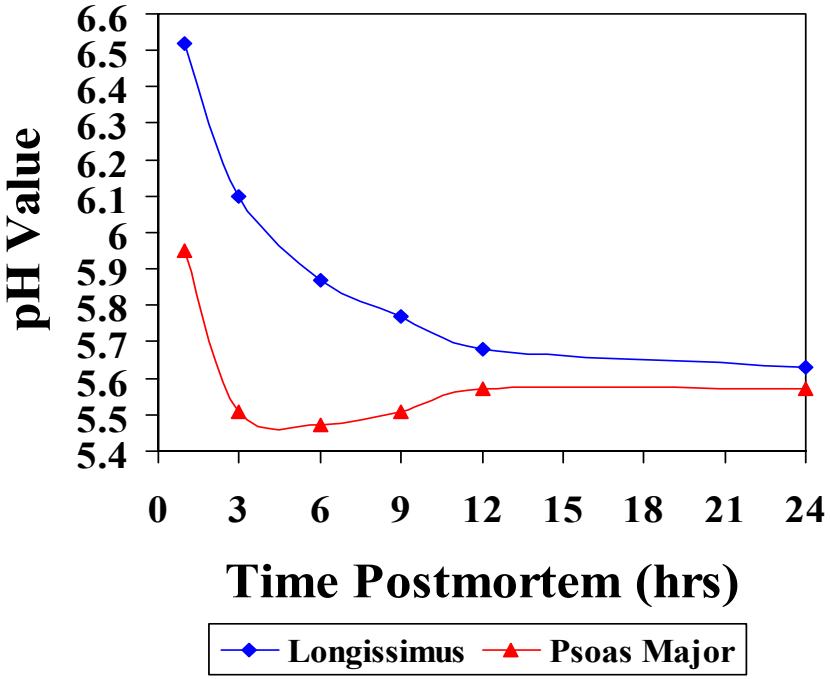
PIC

Traditional pH decline in pork???

Early Postmortem Decline (Pork)

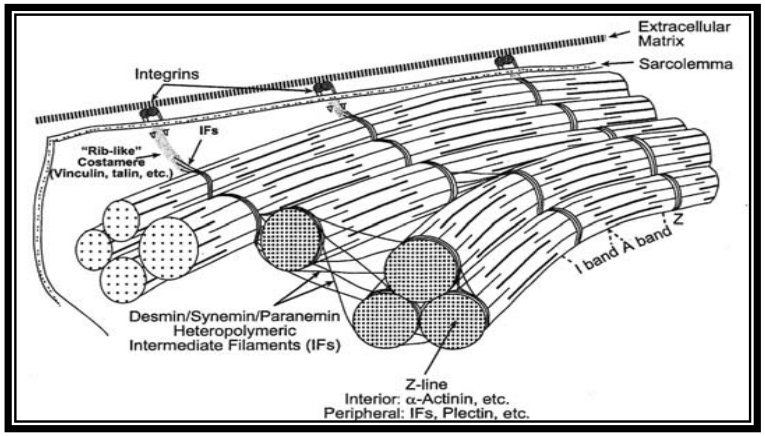


Early Postmortem Decline (Bovine)



(Koohmaraie, et al. 1988. J. Food Sci. 53:407-410.)

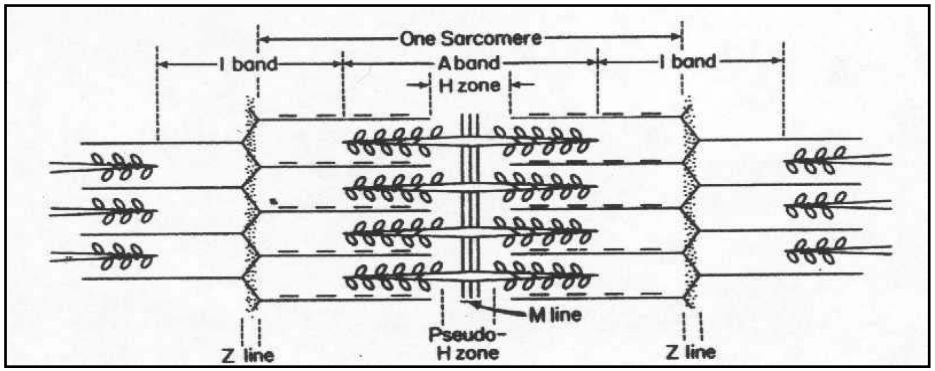
Postmortem proteolysis



(Robson, et al. 1981. RMC Proceedings. 5-11.)

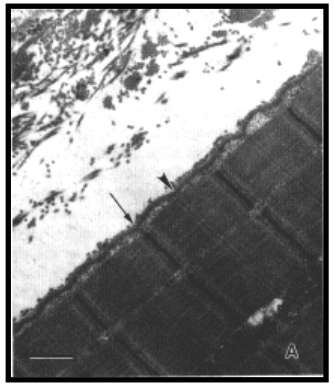
Proteins of Interest

– Desmin
– Titin
– Nebulin
– Troponin T



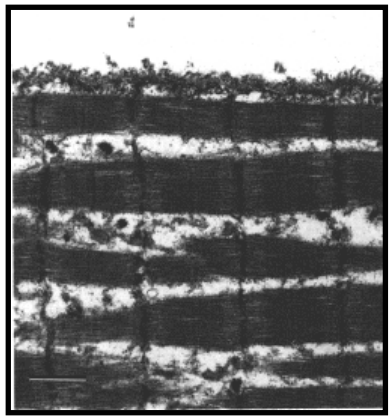
(Goll, et al. 1999. The Calpain System in Muscle Tissue IN: Pharmacology and Toxicology of Calcium-Dependent Protease. P126-160.)

Ultrastructural Changes and Water Holding Capacity



Costameric Degradation

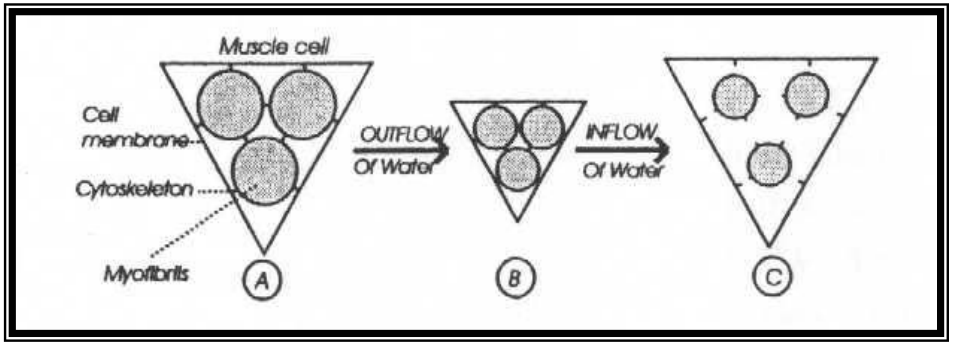
(Taylor et al., 1995. J. Anim. Sci. 73:1351-1367.)



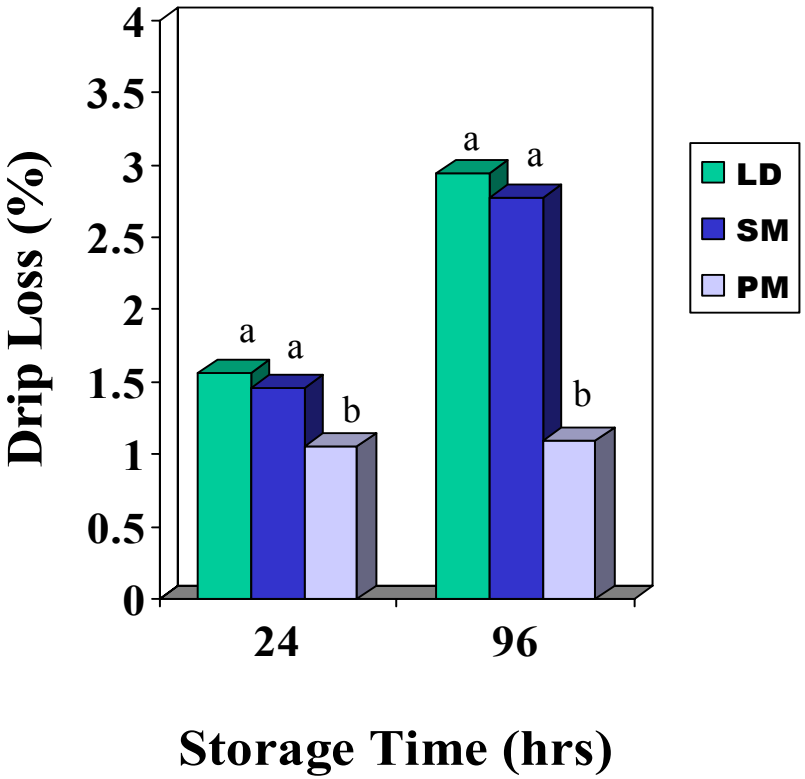
Intermyofibril Degradation

(Taylor et al., 1995. J. Anim. Sci. 73:1351-1367.)

Relationship between Desmin Degradation and Drip Loss



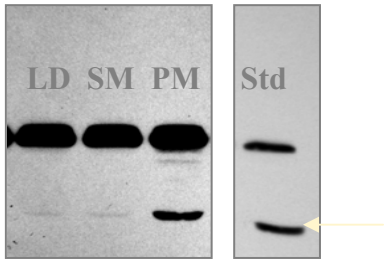
(Kristensen and Purslow. 2001. Meat Sci 58:17-23.)

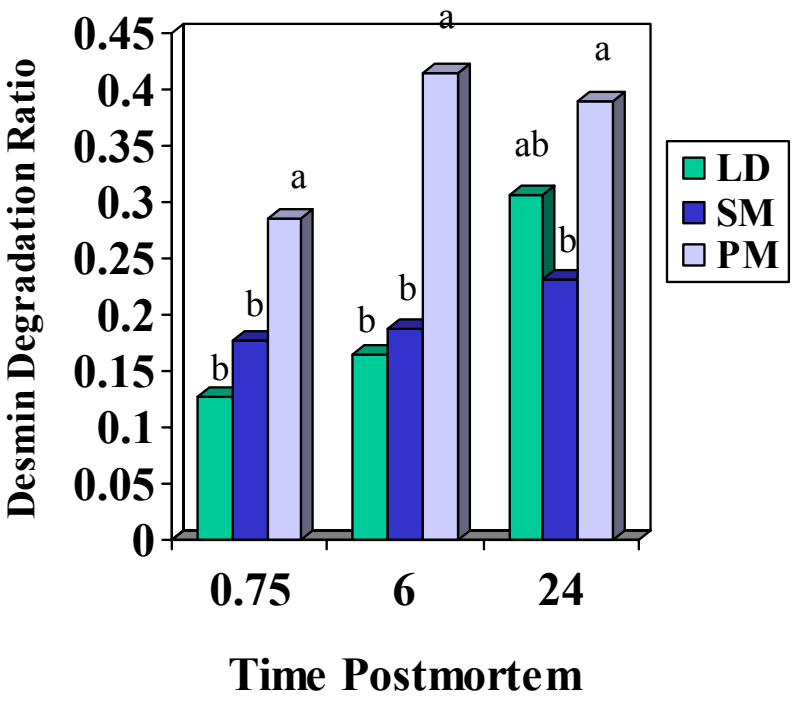


[a,b] Means within the same time point postmortem with different superscripts were significantly different (P<.05) at each time point

Degradation of Desmin Occurs Early Postmortem

6 hours postmortem





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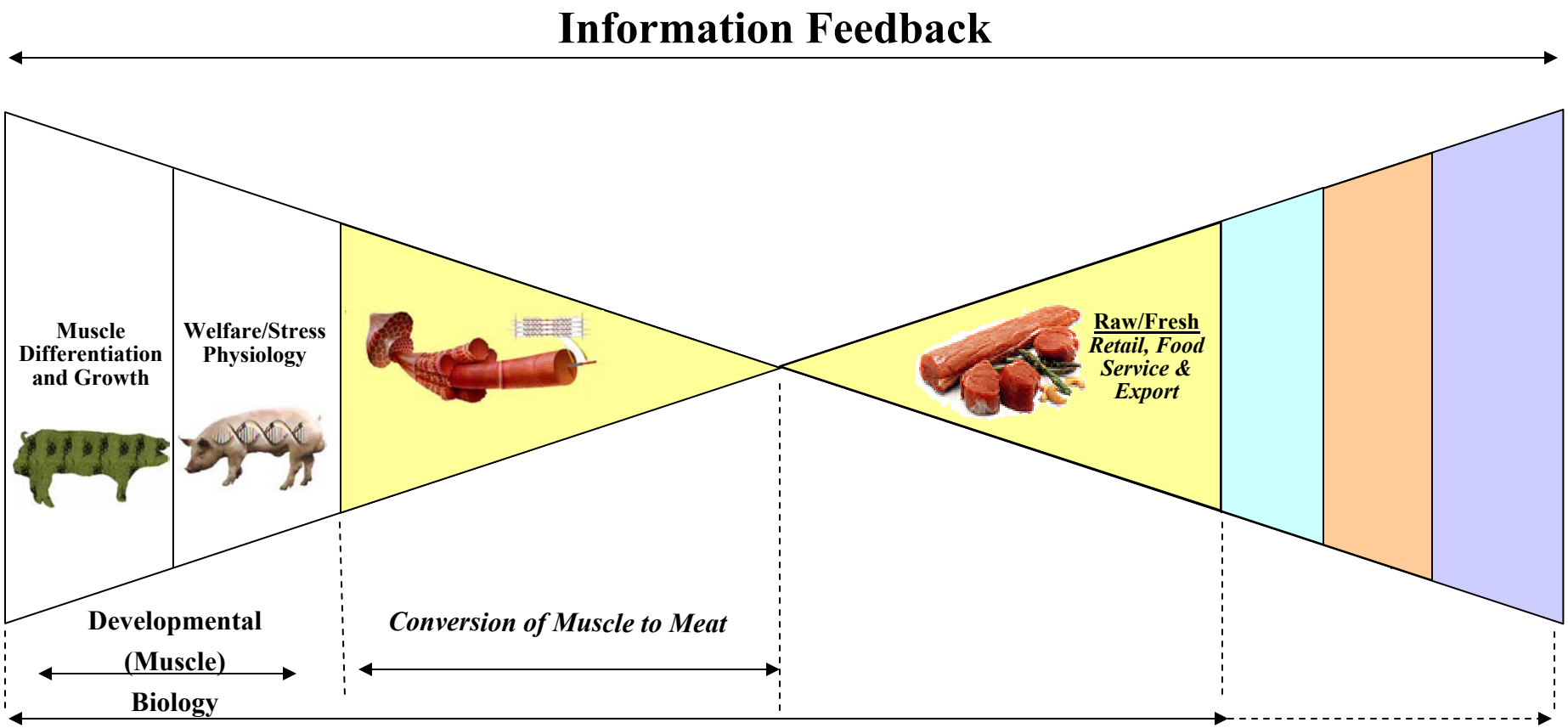
Muscle Foods System

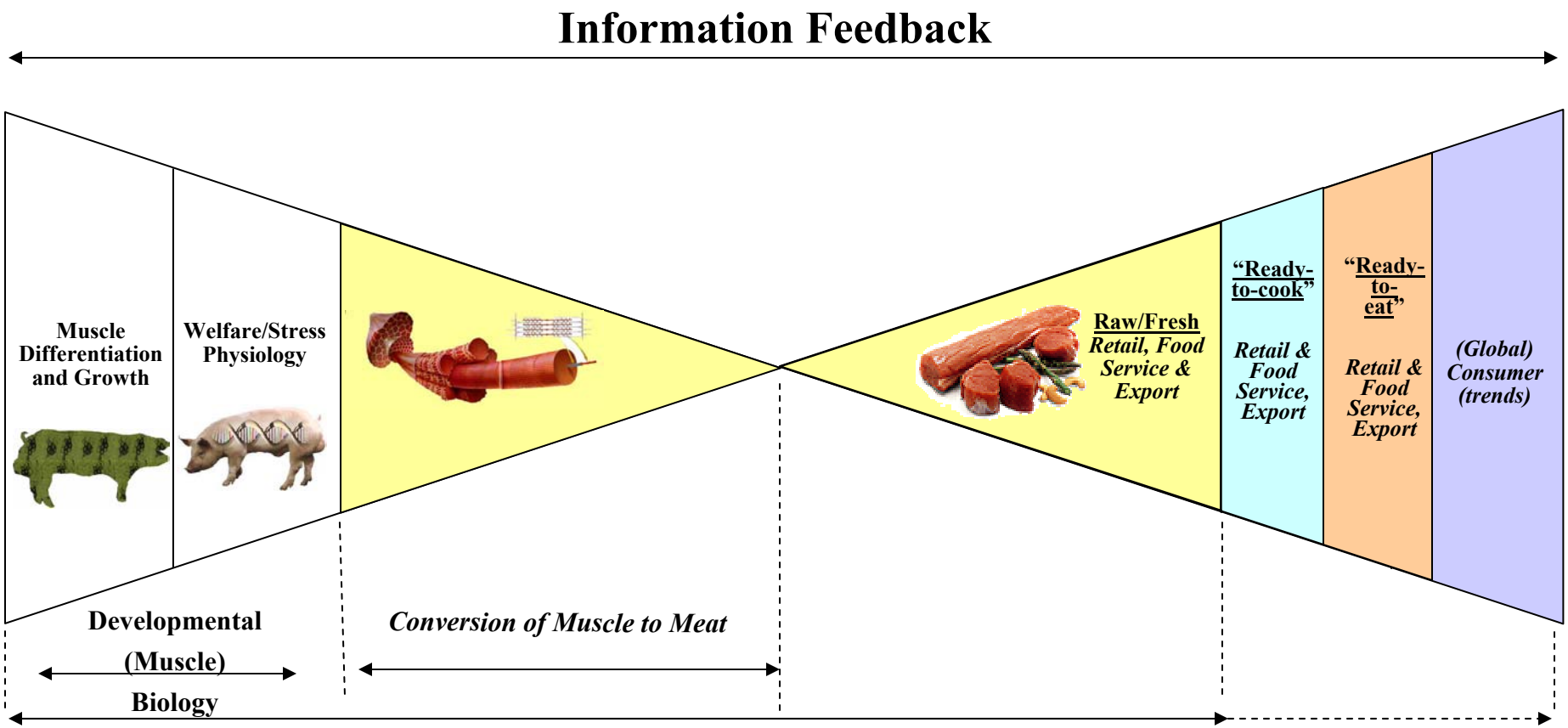


Muscle Foods

Raw Material Quality R&D

- **Develop "muscle-to-meat" kinetic models to predict meat quality**
- **Understand factors underlying formation of ultimate pH**
- **Better understand the economic value of meat quality traits in the supply chain**

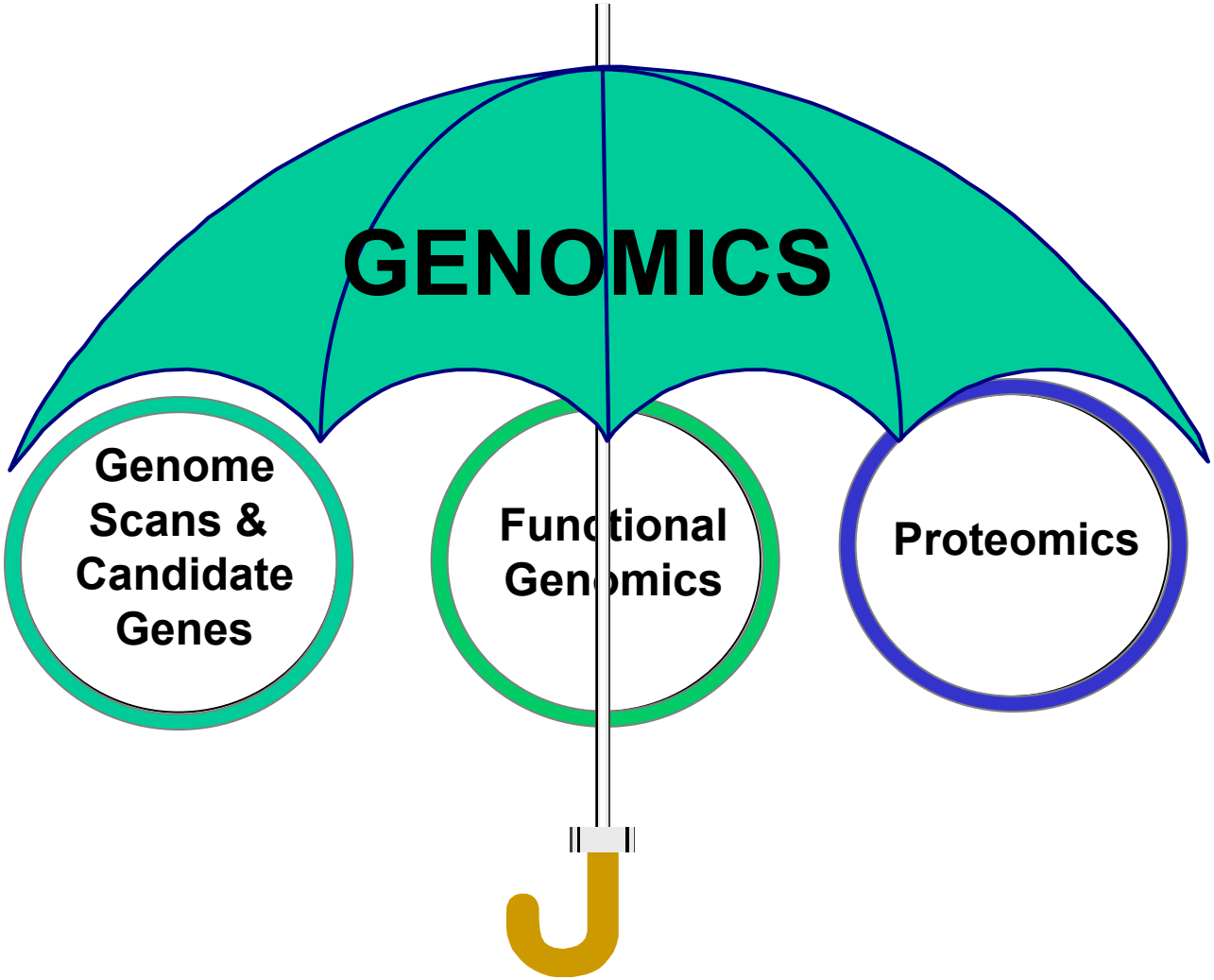
Muscle Foods System



Functional Genomics & Proteomics

Muscle Foods

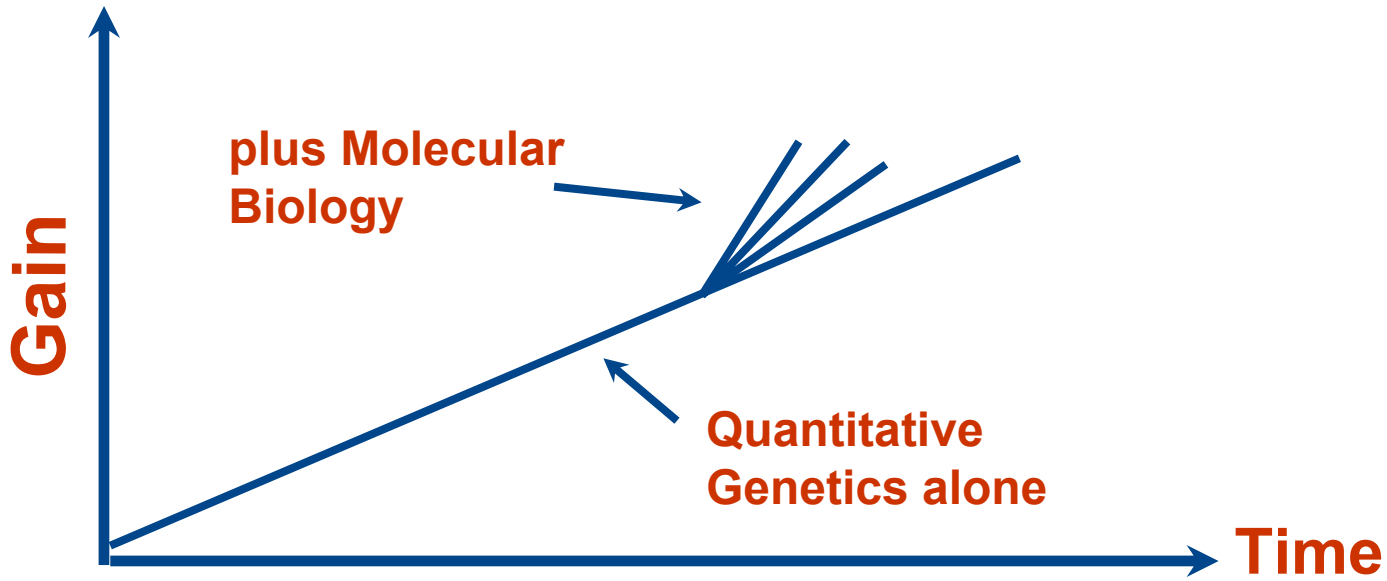
Marker Assisted Selection



Name	Description	Reference
Hal-1843® gene	Malignant hyperthermia – porcine stress syndrome	Fuji *et al.* (1991)
RN gene	Acid pork (Hampshire)	Milan *et al.* (2000)
MC4R	Appetite, fatness and homogeneity of pig carcasses	Kim et *al.* (2000)
BETTERgen™ / IGF2	Lean meat content of muscular breeds	Nezer *et al.* (1999), Jeon *et al.* (1999)
FABPs	Level of intramuscular fat (Duroc)	Gerbens *et al.* (1997, 1998)
Unidentified (QTL)	Intramuscular fat and backfat thickness (Iberian pig)	Ovilo *et al.* (2000)
Unidentified (QTL)	Level of intramuscular fat (Meishan)	Janss *et al.* (1994, 1997)
Unidentified (QTL)	Level of intramuscular fat (Duroc)	Monin *et al.* (1998)
Unidentified (QTL)	Level of intramuscular fat (Meishan)	Renard & Mourot (2000)
Calpain	Level of calpain – pork tenderness	Parr *et al.* (1999)
MyoG (myf4)	Muscle yield	Soumillion *et al.* (1997)
MyHC	Fiber type – pork tenderness	Beuzen *et al.* (2000)
CAST	Level of calpastatin – pork tenderness	Ernst *et al.* (1998)
Unidentified (QTL)	Level of androsterone – boar taint	Fouilloux *et al.* (1997)

Molecular Genetics - Markers

- "Turbo charging" the Quantitative Engine
- Faster genetic improvement
- Differentiate products



Conclusions:

Optimising Genetics

- **Better understanding of economic value of muscle quality traits**
- **Several gene markers affecting muscle quality are being discovered and used in breeding programs**
- **Faster, lower cost implementation of genotyping**
- **Specialized (customized) lines are being developed**

Research Priorities for Pork Industry and Academia

1. Greater understanding of perimortem and early postmortem muscle biology

2. Better understanding of the economic value of meat quality attributes

3. Precise breeding/production systems should be established to insure acceptable animal/stress welfare physiological behavior

4. Implement MQ focused statistical process procedures to ensure sustainability of the production systems