An Introduction to Poultry Nutrition

Rick Kleyn

SPESFEED CONSULTING

Introduction

- Nutrition is not complicated.
- Science - not an art form.
- Our knowledge is good - not complete.
- Simple explanation all that is required.
- Adverts for human food have muddied the water.

Feed

- Feed comprises four major components:
  - Water
  - Energy (mostly sugars and fats)
  - Nutrients (Protein, vitamins and minerals)
  - Non-nutritive additives

The Bird

- Converts food (grain, beans etc.)
- Into food components (energy & nutrients).
- Consume nutrients – not specific food types!

The Bird

- The bird requires food for four things:
  - Maintenance (determined by body size)
  - Production (Growth and/or egg production)
  - Immunity
  - Activity

Energy – “the fuel of life”

Energy

- Animals dependent on molecular energy.
- Birds require energy to “work”.
  - The business of living (maintenance)
  - Production (meat and/or eggs)
- Store surplus energy as fat.

Uses of Energy

- Maintenance requirements:
  - Basal metabolism
  - Adaptive thermogenesis
  - Dietary thermogenesis
  - Physical activity
- Has first call on any energy consumed

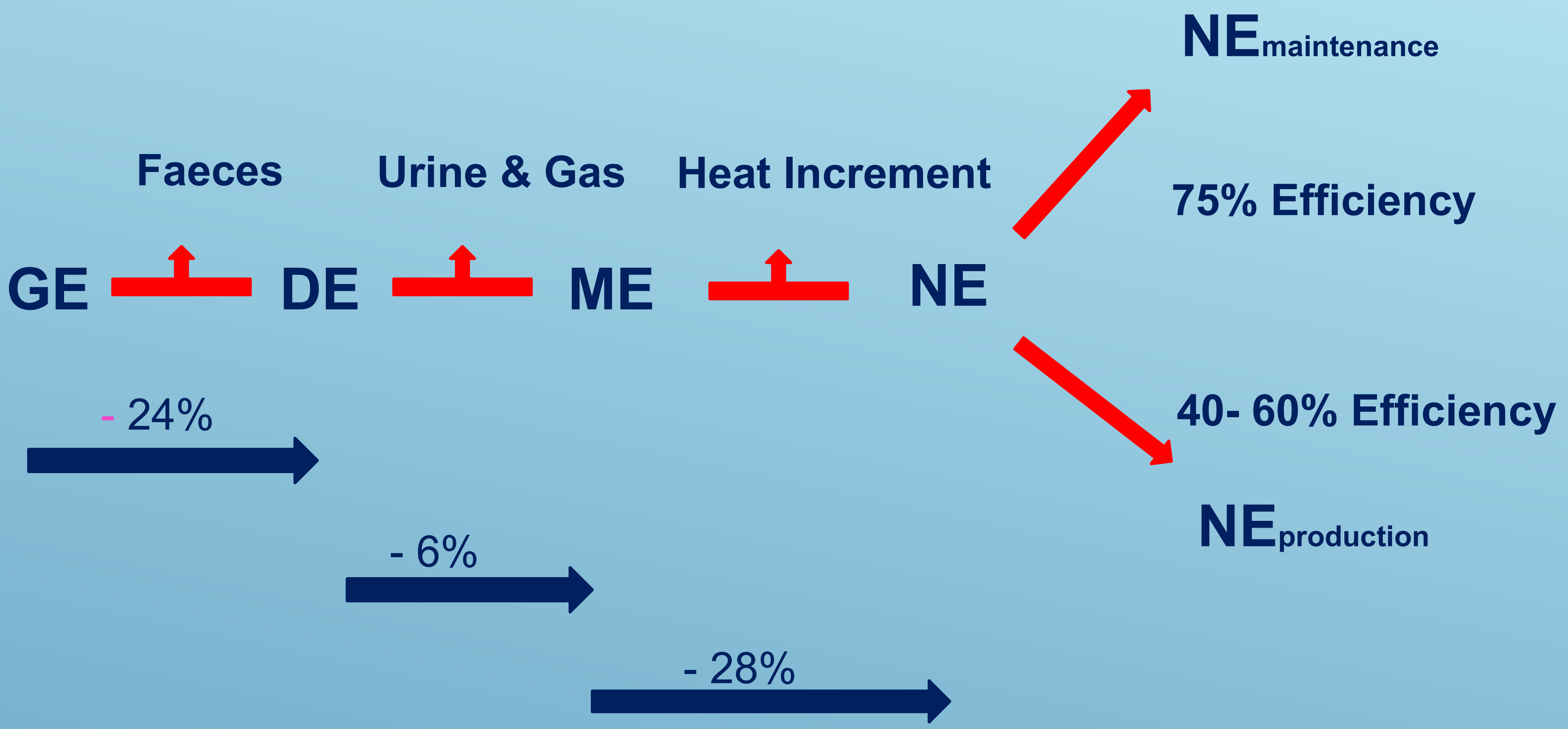
Uses of Energy

- Production requirements:
  - Energy within products (growth, eggs)
  - Thermo genesis associated with their synthesis

Energetics

- Must furnish the bird with adequate calories on each day of cycle.
- Need to know how to quantify this.
- Require the use of energy ‘systems’
  - Determine bird requirements.
  - Evaluate ingredients.
  - Formulate diets.
- ‘Partition’ energy to understand and measure it.

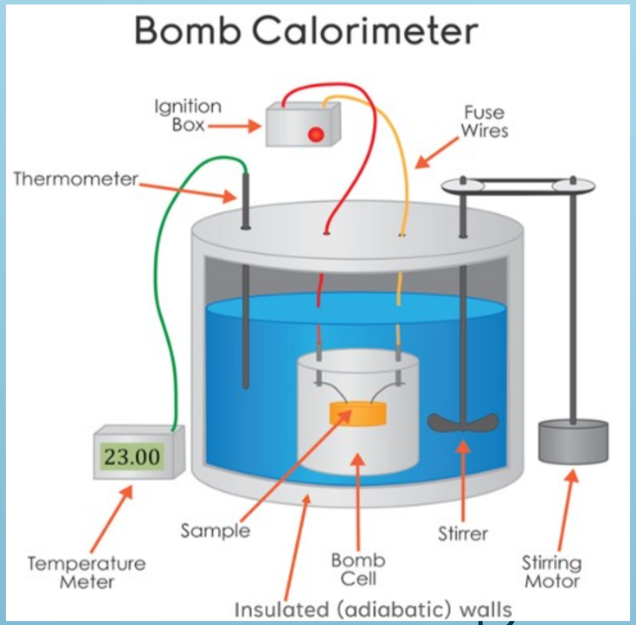
Energy Partitioning



Estimates from Choct, (2017)

Which energy system to use?

- GE is meaningless in nutritional terms.
- DE – more accurate, not used in poultry.
- ME – most widely used energy system.
- NE is theoretically the best – expensive and difficult to measure.



ME System

- ME system – de facto standard for the poultry industry.
- ME - ignores heat increment.
- True ME – considers endogenous losses.
- Apparent ME – does not.
- Values proportional at normal feed intake.

Nitrogen Correction

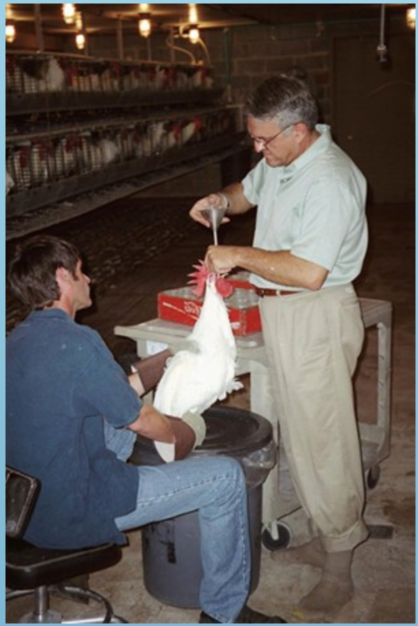
- Assume – energy-yielding nutrients used.
  - Retained protein is deaminated.
  - Some N is, however retained.
- Correction factor higher for ingredients promoting N-retention.
- In theory - decreased variation in assays.
- Use AME_n
- WPSA valued for AME_n used by primary breeders

Other Systems

- Theory - an NE system is the ultimate goal.
- Schothorst Feed Research and CVB.
  - Modified ME system.
  - Energy of protein – reduced 15% broilers.
- Brazlian
- INRAE

The ME system

- All energy systems – based ME determination and mathematical correction.
- Yet – ME determination still not resolved (Mateos, 2018)
  - Perfect world - in vivo methods (expensive, accurate).
  - Not sure what ingredients were tested.
  - Chemical analyses (ignores digestibility).
  - Predictive equations (outdated data)
  - “Feed” tables (feedtables.com; FEDNA)



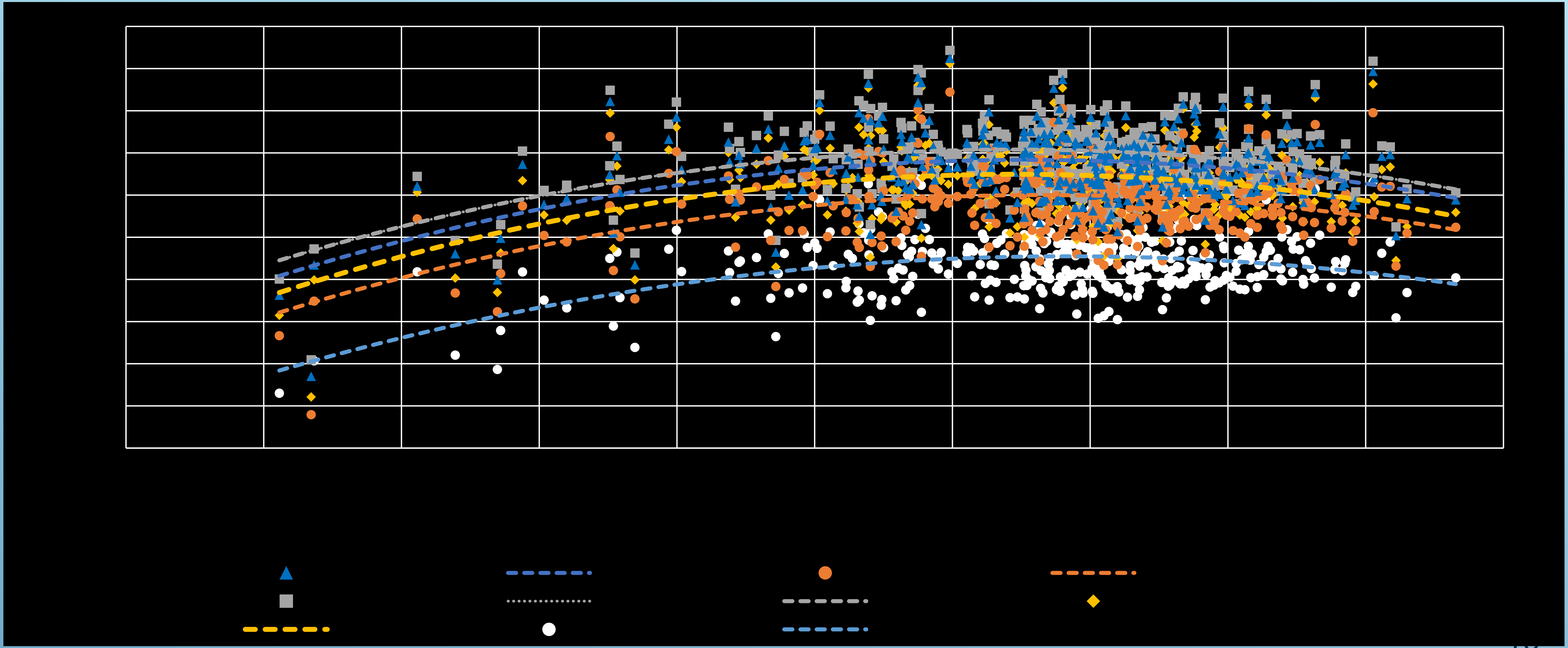
Hierarchy of Energy Values

	AME_n	FEDNA (2010)	Feedstuffs (2016)	CVB (2012)
System Used	AME_n	AME_n	TME_n	ME Layer
Maize	1.00	1.00	1.00	1.00
Wheat	0.94	0.97	0.95	0.97
Soya 47%	0.69	0.70	0.72	0.58
FFS	0.98	1.08	1.00	0.98
Sunflower 36%	0.52	0.53	0.67	0.46
Rapeseed Meal	0.58	0.53	0.53	0.51
Wheat Middlings[4]	0.63	0.56	0.63	0.43
Soya Oil	2.61	2.74	2.6	2.66

Hierarchy of Energy Values

	Comm Australia (2018)	FEDNA (2010)	Feedstuffs (2016)	CVB (2012)	UNE (Swick et al., 2016)
System Used	AME_n	AME_n	TME_n	ME Layer	NE Layer
Relative Value (%)[1]	100	100	106	98	80

Energy System and Egg Output



Energy System and Egg Output

	AME_n	INRAE	Brazil	CVB	NE
AME_n	1.000				
INRAE	0.992	1.000			
Brazil	0.998	0.988	1.000		
CVB	0.990	0.991	0.988	1.000	
NE	0.974	0.987	0.963	0.989	1.000

Shortcomings of Energy Systems

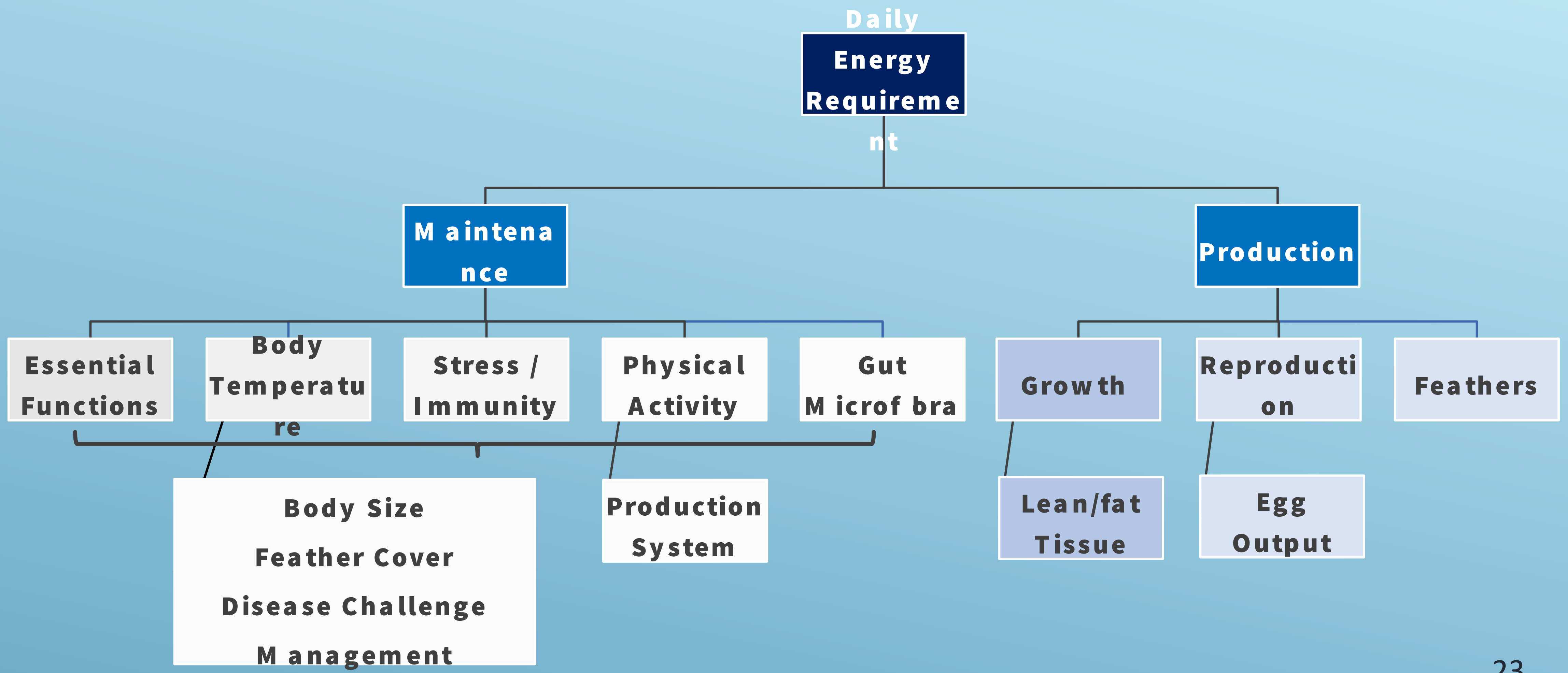
- No distinction for efficiency of utilisation (size, body composition, egg output)
- Assume energy contribution is linear.
- Digestibility differs between young and old.
- Multiple energy systems – only add to the confusion
- Energy is a characteristic of the animal consuming the diet – not of the diet itself.

How Much Energy?

- Body temperature (hot or cold)
- Size – bigger = more.
- Insulation - feathering
- Growth – faster = more
- Reproduction (eggs)
- Activity

Factors Affecting Energy Requirements

(Source: Natalie Chrystal)



How Much Energy?

- Body temperature (hot or cold)
- Size – bigger = more.
- Insulation
- Growth – faster = more
- Reproduction (eggs)
- Activity

Factors determining energy requirement

- Size & insulation (feather cover)
- Egg output (9 – 11 kJ/g egg)
- ME requirement
  - Layers - 360 kJ/kg $W^{.75}$ (MacDonald 1985)
  - Layers - 350 kJ/kg (Kleyn 2023)
  - Broilers - 650 kJ/kg $W^{0.66}$ (Lopez et al., 2005)

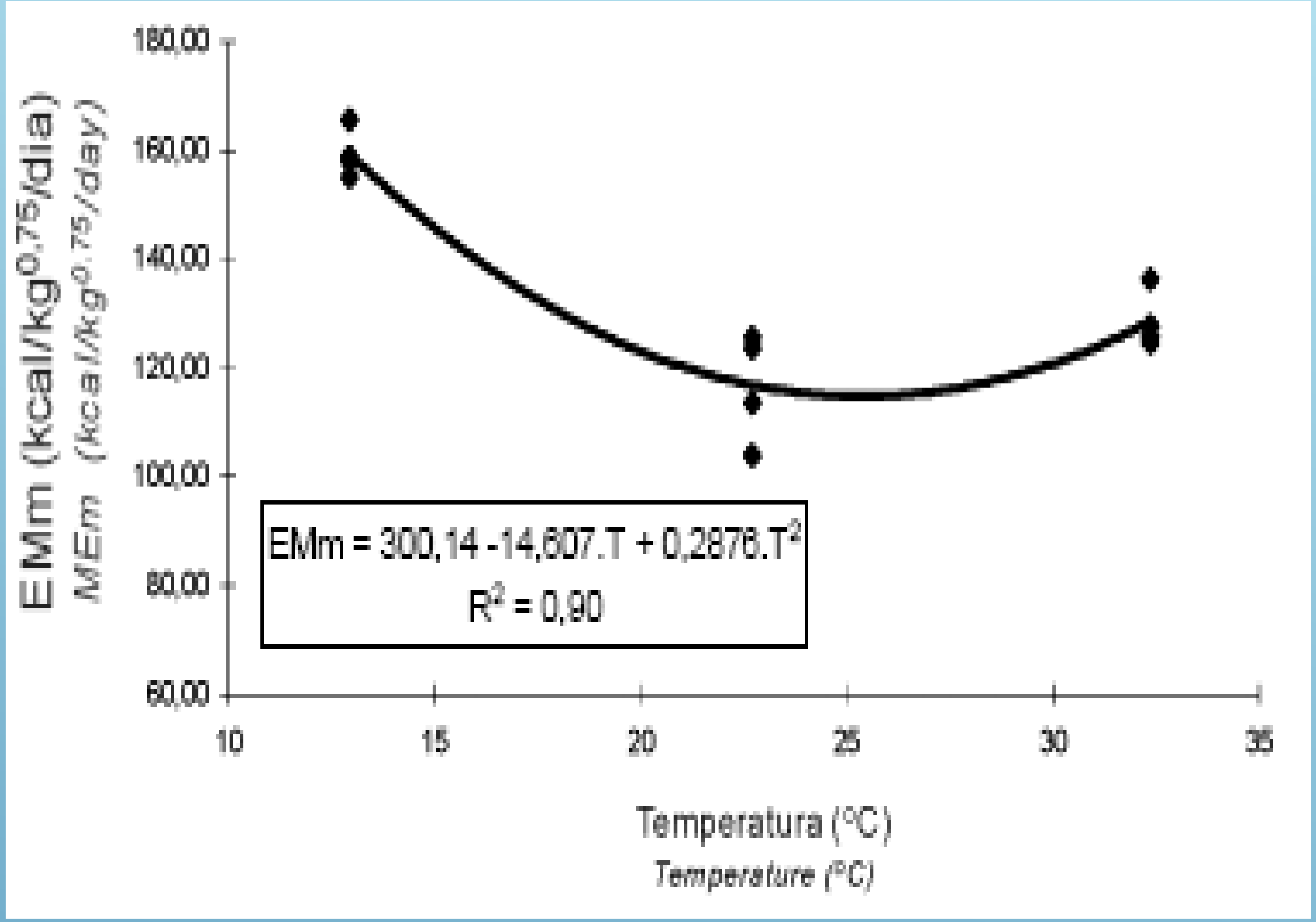
    where W = body weight

Growth

$$ME = 15\ lean + 46.5\ lipid$$

- Where
  - ME = metabolizable energy requirement in joules
  - lean = grams of lean growth
  - lipid = grams of lipid growth

Maintenance and Temperature



Plumage

- Feather cover:
  - Bird age - feather cover reduced.
  - 50% of normal - 7g more feed (23.9° C)
  - Feather pecking - behavioural problem.

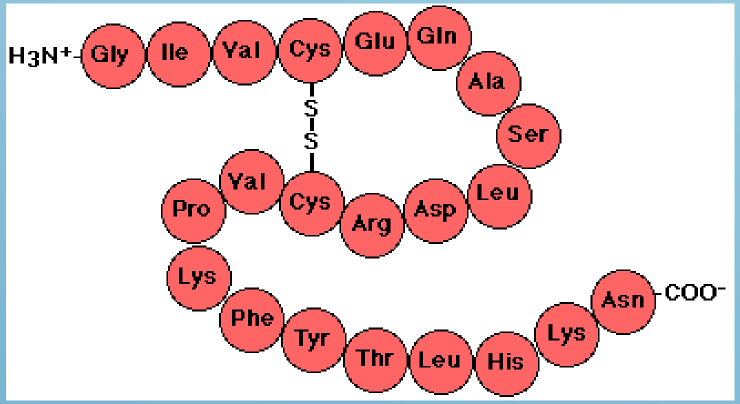
Protein

Protein Structure

- 50% of animal cell DM is protein
- Protein an N containing compound (6.25).
- Use Crude Protein as an indicator.
- Not that meaningful – easy to analyse.

Protein Structure

- Only about 80% of Crude Protein is “True”.
- True protein – chains of Amino Acid.
- Structure and amino acid composition determines protein function.



Protein Structure

- Plants can produce all 22 amino acids
- Used to believe animal protein was special
- Structure and amino acid composition determines protein function.
- Surplus amino acids can not be stored.
- Insulin controls level of amino acid pool.

Protein and Amino Acids

- Surplus AA – can't be stored.
- Catabolized:
    - Nitrogen –excreted in urine.
    - Carbon Backbone
- Individual AA utilization impaired by either over or under-supply.

Protein Requirements

- Nutritionists - strive to supply each flock.
  - Correct levels of AA on each day of production cycle.
- Changes as birds age.
- Supply each flock “ideal protein”.
- Correct levels of essential amino acids.
- Sufficient N for synthesis on non-essentials.
- Understanding protein continues to evolve.

Nutritional Classification of Amino Acids

(after Leeson, 2001)

Protein Requirements

(Alhotan and Pesti, 2016)

- Requirements for EAA well understood.
- Less known about secondary - NEAA
- NEAA implies - not needed in the diet.
- Individual AA utilization - impaired by over and/or under-supply.
- Surplus EAA – are in essence NEAA.
- Limits in NEAA may be because of:
  - May be a shortage of precursors.
  - Metabolic processes too slow .

EAA – essential amino acid
NEAA – non-essential amino acid

Factors Determining Requirement

- Maintenance
- Linked to body size in a linear manner.
- Growth
  - Highest in young bird.
  - Carcass 17.5% protein.

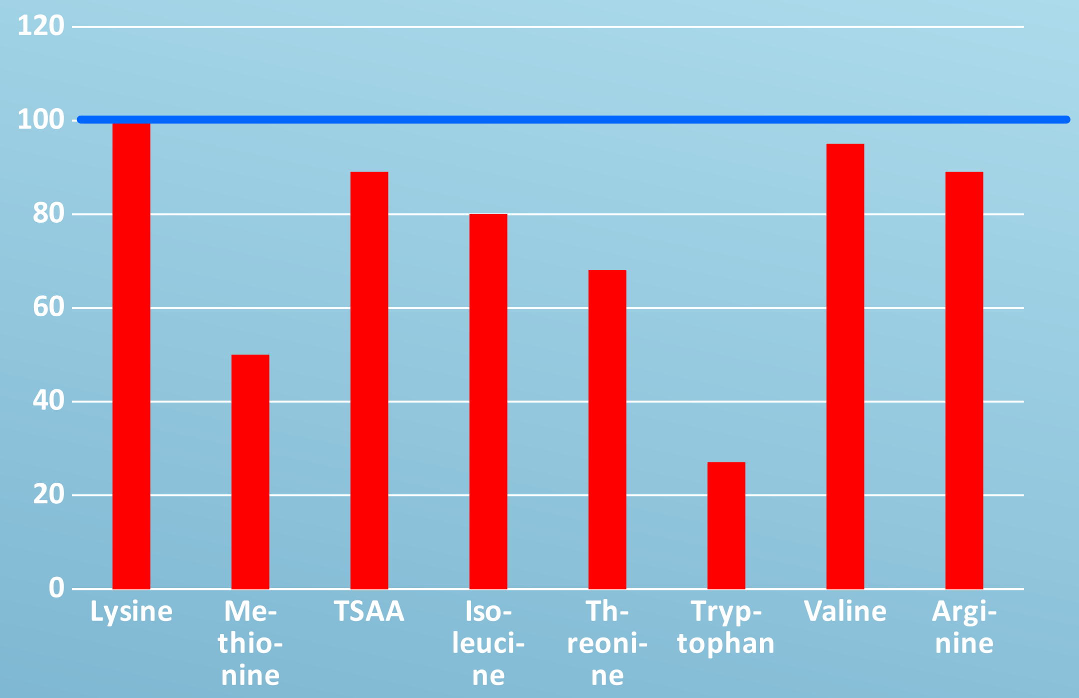
Factors Determining Requirement

- Immune reaction
- Reproduction
  - Eggs.
  - 10 mg Lysine gram egg.
- Feathers
  - No turnover
  - High in sulphur-containing amino acids.

Ideal Protein

- Amino acid supply (profile) all important.
- Supplies optimum essential amino acid balance (perfect?).
- Sufficient amino N for synthesis of other amino acids.
- Use Lysine as our benchmark
  - Mostly first limiting.
  - Extensively studied
  - Easy to analyse for.

Ideal Protein Requirement - Eggs

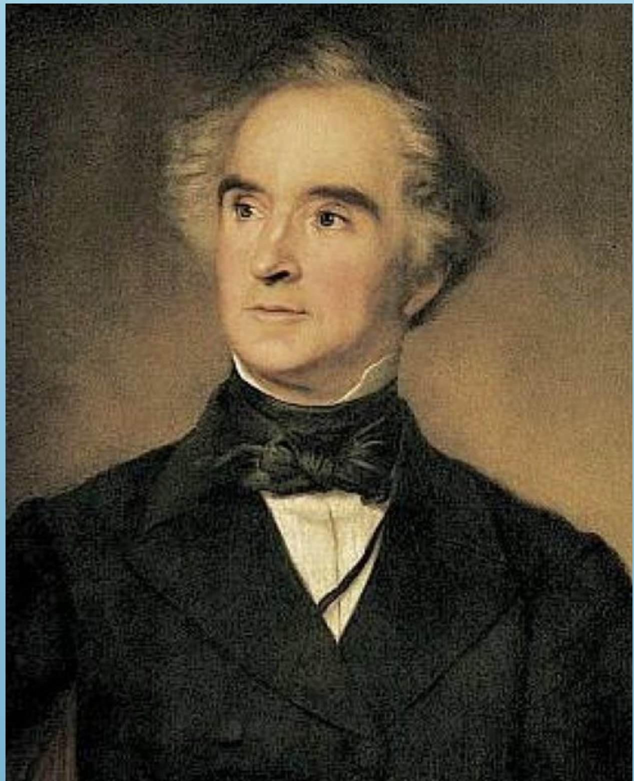


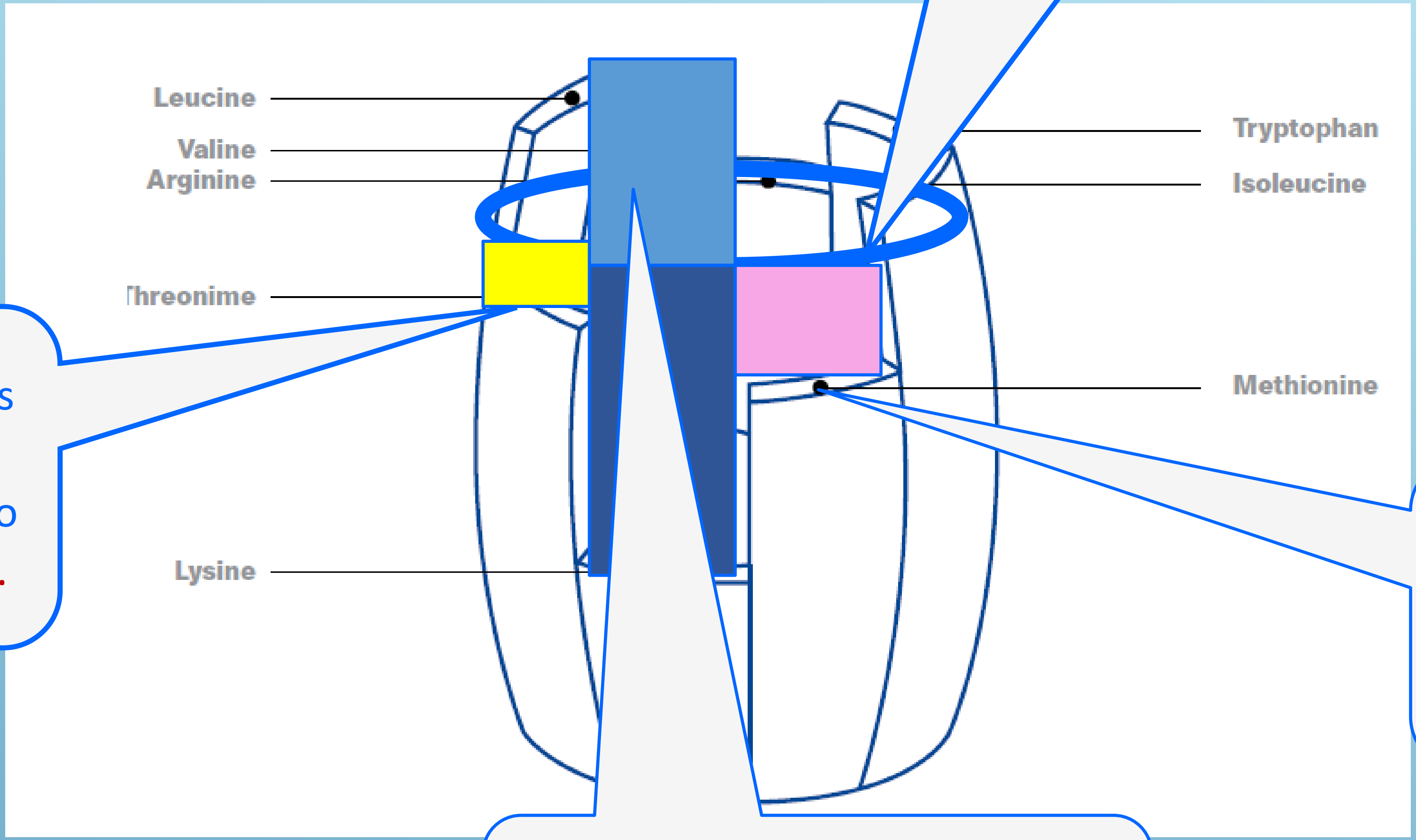
Ideal Amino Acid Profiles

Source	CVB -2006	Lemme -2009	Brazilain (2017)	Elliot (2020)	Macelline (2021)
Av Lysine Requirement (mg/d)	700	810	710-840	800	750
Lys	100	100	100	100	100
Met	50	50	49	44	36
TSAA	93	91	90	82	86
Thr	66	70	79	71	67
Trp	19	21	23	19	21
Arg	-	104	100	107	101
Ile	79	80	76	75	73
Val	101	88	95		89

The Past

- Liebig's law of the minimum (1840):
- “Growth is dictated not by total resources available, but by the scarcest resource (limiting factor)”





1. The target – 100% of requirement for each amino acid.

2. Meet the requirement for lysine. Note – methionine now limits protein quality

3. Exceed requirement for lys – no improvement in protein quality.

4. Meeting requirements for methionine and the threonine is necessary to achieve an ideal protein.

Ending Off

- All components of diet equally important.
- Energy:
  - Contained in tissues.
  - Required to fuel building process.
- Nutrients:
  - Structural function in all tissues.
  - Regulate body function.