# Unravelling Some of the Mysteries of Mineral Supplementation

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# MINERALS

- Macro-minerals - structural, osmotic balance, major signalling: g/kg DMI
  - calcium, phosphorus, magnesium, sulphur, sodium, potassium, chloride
- Trace minerals - co-factors, signalling: mg/kg DMI
  - copper, cobalt, selenium, zinc, manganese, iron, iodine, chromium, molybdenum
- Ultra-trace minerals - roles uncertain: µg/kg DMI
  - vanadium, tin, nickel, arsenic, fluorine, silicon
- Minerals that may be beneficial
  - aluminium, boron, cadmium, lithium, lead, rubidium

# DEFINING REQUIREMENTS

- Maintenance
- Work
- Reproduction
- Growth
- Animal demand (g) vs feed supply (g/kg)?

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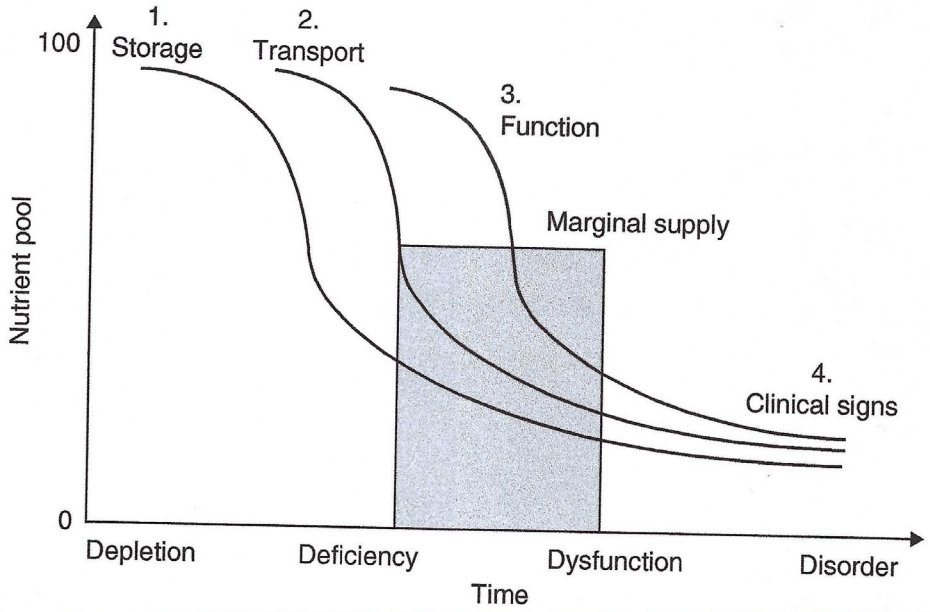
# MINERAL RECONCILIATION

- For convenience considered in pools
  - storage, transport, functional
- Functional Pool
  - structural - bone, teeth, tissue integrity
  - physiological - osmolytes, acid-base balance
  - catalytic - metalloenzymes, hormones, co-enzymes
  - regulatory - cell signalling, gene expression
- Balance at animal level
  - absorption, retention, excretion
- Balance at system level
  - imports & exports - animal, forage, grain, leaching, run-off

# NUTRIENT CLASSIFICATION BY ‘TYPE’

- Animals respond to nutrient deprivation in one of two ways
- Type 1: continue to grow, deplete tissue stores; typified by specific clinical disorders; Se, Fe, Ca, Co, Cu, Mn, I, fat soluble vitamins
- Type 2: stop growth, maintain tissue concentrations; typified by non-specific reduced performance; S, K, Na, Mg, Zn, P, energy, protein

# MINERAL DEPRIVATION



# WHY SUPPLEMENT?

- Feed conversion efficiency
- Animal health & welfare
- Facilitate genetic potential
- Consistent, predictable performance
- Rebuild reserves
- Counteract plant secondary metabolites/anti-nutritional factors/toxicities - copper, cyanide, oxalate, tannins
- Induce metabolic change - anionic salts
- Nutrigenomics - impact on gene transcription, protein expression & metabolism

# PRINCIPLES TO CONSIDER

- Supply v's demand
- Impact of genetic improvement, stocking rates
- Depletion & dissipation of world reserves
- Disruption of natural nutrient cycles
- Primary limiting nutrients - wine barrel analogy
- Biological variation between enterprises, individuals & age groups
- Reduced opportunity for livestock to exercise 'nutritional wisdom'
- Limited opportunity for livestock to evolve & develop & produce in the presence of their natural biome
- ALL metabolic activity is linked either directly or indirectly
  - requirement for one mineral invariably linked to activity of other(s)

# METHODS OF SUPPLEMENTATION

- In feed
- Water medication - Beachport, Anitone, direct injection
- Drench - Anitone
- Injection - SA & LA
- Slow-release boluses
- Soil & foliar applications
- Voluntary intake preparations - liquids (Anipro, MU8), loose licks, blocks, smorgasbords

# ERRORS

- Type I Error (error of commission) - “I did the wrong thing”

- Type II Error (error of omission) - “I failed to do the right thing”

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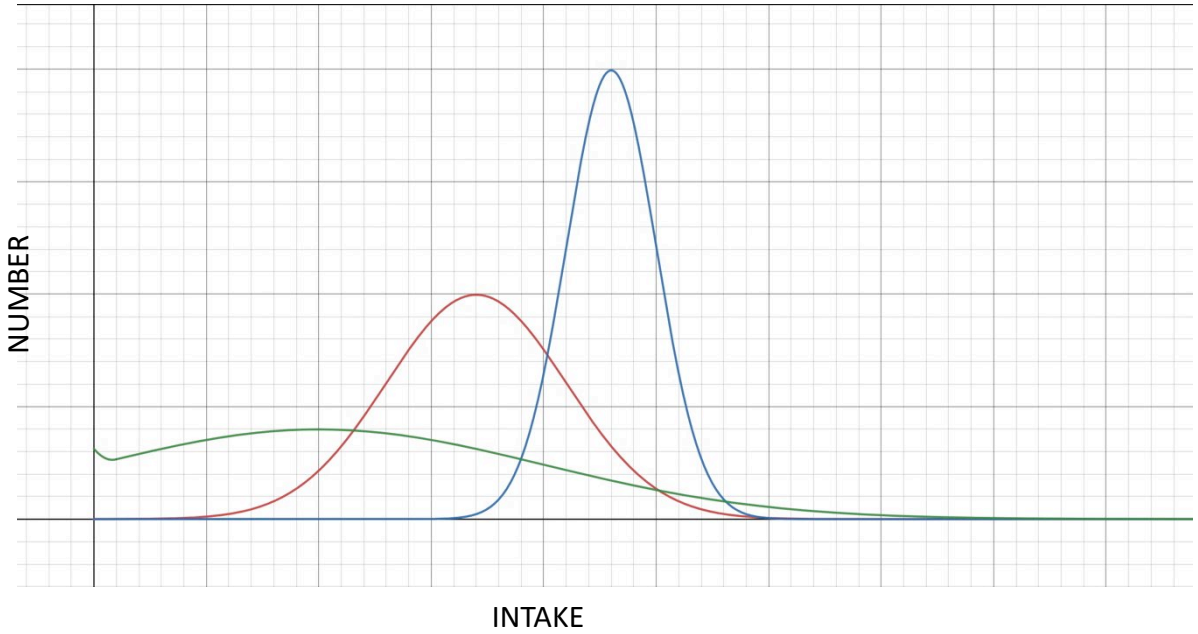
# VOLUNTARY INTAKE SUPPLEMENTATION

- See things from the animal's perspective (Temple Grandin)
- Strategic approach
- Livestock need to develop familiarity
  - imprinting, mentoring, possibly need opportunity to experience consequences
- Neophobia
  - animals of prey inherently fearful but inquisitive
- Start early
  - takes time for a novel experience to work e.g. ~10 weeks for loose lick to plateau
- Importance of interactions
  - water TDS, environmental salt, spatial distributions, feeding system, number of stations, feed quality, herd/flock dynamics, physiological state
- Palatability modified by accelerators & brakes (salt, molasses, protein meal)
- Need significant target intake
  - proportion of 'non-consumers' & variability in intake are greater when average intake is low (<100g in cattle)

# INTAKE OF FREE CHOICE SUPPLEMENTS

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# ASSESSING MINERAL STATUS

**Soil Status → Plant Status → ANIMAL STATUS ← Biological Variation**

↑ ↑ ↑

**Rhizoshere Rumen Environment**

- Not a ‘straight line relationship’
- Difficult to reliably assess animal status
- Significant variation between individuals
- Blood is a conduit - useful for macro-minerals
- Liver storage of some micros - difficult
- Hair - confounding factors
- Local knowledge
- *Nutrient Requirements of Domesticated Ruminants* as a starting point

# PHASES OF MINERAL DEPRIVATION

- Depletion
- Deficiency
- Disfunction
- Disorder

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# DOSE RESPONSE

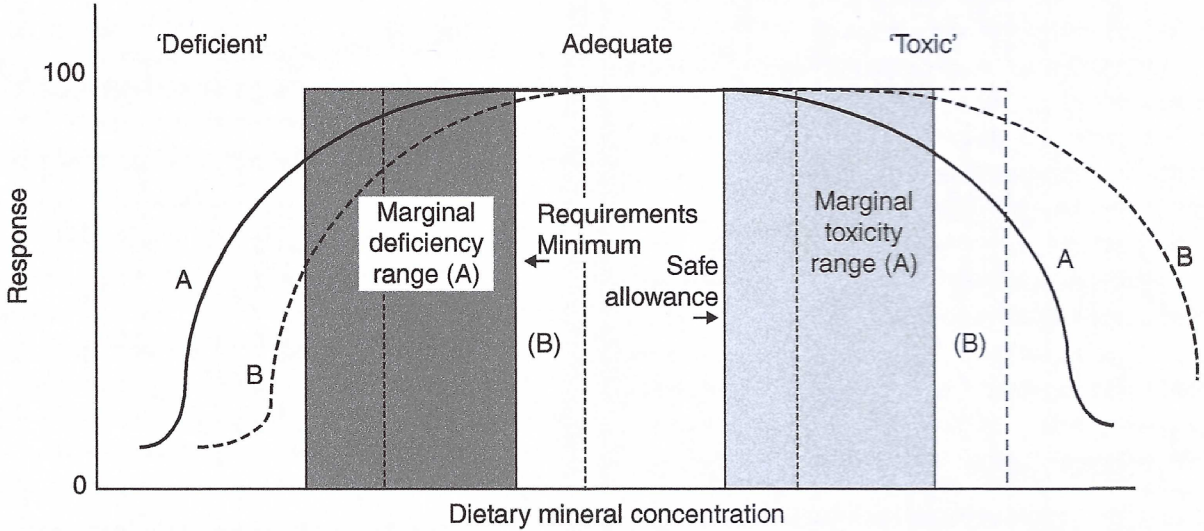


**Fig. 1.5.** The dose–response relationship between mineral supply and animal production, showing marginal bands between the central adequate band and either inadequate or toxic dietary concentrations: all bands move right as availability of mineral declines; thus A represents the more and B the lesser absorbable of two mineral sources. 'Requirements' are variously set within the central band, ranging from minimum requirements to safe allowances, depending on the caution of formulators in allowing for differences in variables such as availability.

# IMPACT OF BIO-AVAILABILITY

- $/utilised unit
- Environmental impact
- Quality usually $\alpha$ price
- Solubility is a potential on-farm measure of quality of inorganics
- Organic complexes have different mode of absorption & typically higher rate of retention

# FACTORS AFFECTING BIO-AVAILABLITY

- Form
- Solubility
- Interactions
- Intake
- Demand (physiological state, reserves)
- Rumen pH
- Fibre levels

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# WHEN TO SUPPLEMENT

- When a mineral(s) becomes first limiting nutrient
- Increased demand; limited supply
- Might be related to the production or reproduction cycle
- Pasture/browse composition
- Stage of plant growth cycle

# SPECIFIC SITUATIONS

- Feeding grain, especially wheat: calcium, sodium
- Grazing winter cereals, especially wheat: calcium, sodium, magnesium; note the possible shortcomings of 40:20:40
- Lush, grass-dominant pasture after the ‘break’; adaptation, low DMI, high potash, high Vit A, high phosphorus, high PUFA
- Wet season P supplementation in the rangelands

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# SPECIAL MENTION FOR SELENIUM

- Activity mainly via >25 seleno-proteins
  - all involved in reducing ‘reactive oxygen species’ -> indirect influence on wide range of physiological processes
- Glutathione peroxidase
  - family of at least 6 selenium containing enzymes, different locations & substrate preferences, reduce peroxides, co-operate with other enzymes & vitamin E in protection from oxidative damage
- Vitamin E
  - poorly transferred across the placenta -> reliance on colostral transfer -> significant depletion of ewe levels -> implications
- T4 -> T3
  - involved in activation of thyroid hormone in brown adipose tissue of the new-born -> implications for thermogenesis

# COMPLICATING FACTORS

- Feed deprivation
- Stress e.g. inclement weather
- Exercise
- Change of diet
- Excesses e.g. magnesium
- Oxalates

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# INTERACTIONS

- Between each other
- Competition for transport mechanisms (absorption)
- Other nutrients e.g. ME, CP
- Physiological state
- Genetics & epigenetics
- All metabolic processes are linked

# TAKE HOME MESSAGES

- Nutrient deficiencies rob performance long before obvious clinical signs
- Have a plan that fits available resources
- Make sure the plan is cost-effective

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# Tools and resources

- MLA
- FutureBeef
- Nutrient Requirement of Domesticated Ruminants: Standing Committee on Agriculture2007
- Animal Nutrition Science: Gordon McL. Dryden 2008
- Mineral Nutrition of Livestock: Neville F. Suttle 5th Ed 2022

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