Outline

- Yesterday, the good
  - Fertiliser
- Today, the good and the bad
  - Pollution
- N and P
  - Cattle & pigs
  - Efficiency

Message

- Manure is fascinating!
- Feed utilisation efficiency affects:
  - Polluting potential of manure/slurry
    - Demand for feed nutrients
      - Farmer income

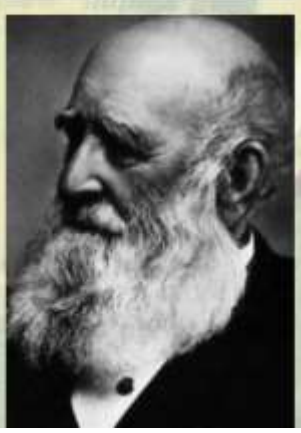
1830s

Dramatic advances in the understanding of fertilisers

- Early fertilisers were crushed bones
  - Escher (1835)
    - $Ca_3(PO_4)_2 + 2\ H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2\ CaSO_4$
- Prof. Justis von Liebig
  - Explained importance of manures and their uptake by plants

    'Chemistry in its Application to Agriculture and Physiology'
    (British Association, 1837)
  - Believed plants were able to obtain N from the air!

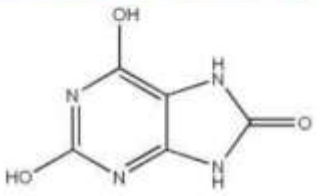
John Lawes & Henry Gilbert



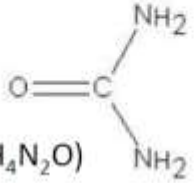
- John Laws (Rothamsted, Hertfordshire)
  - Manufactured superphosphate from bones and coprolites (Deptford Creek, 1843)
- Henry Gilbert
  - Appointed to manage Rothamsted trials
- Classical Experiments (1843 - present)
  - Demonstrated conclusively that plants need N for healthy growth

Guano (1842 – 1870)

- First true compound fertiliser
  - Blend of nitrogen, phosphates and potash
- High N content
  - Uric acid *cf.* urea
- Islands off Peru
  - Favourable weather conditions
  - Sea birds
    - 11,000 tonnes guano/year
    - Deposits 60 meters thick
- 1870
  - 280,000 tonnes imported



Uric acid ($C_5H_4N_4O_3$)



Urea (CH_4N_2O)

Guano….

- Antony Gibbs & Sons (1842-1861)

  The house of Gibbs that made their dibs
  By selling the turds of foreign birds

  → Fertiliser business became part of Fisons
  → Merchant Bank taken over by HSBC (1981)

- London's sewage system
- Samuel Plimsoll
  - Merchant Shipping Act (1876)
    - Plimsoll Line
- (**S**hip **H**igh **I**n **T**ransit)

Manure (& slurry) today

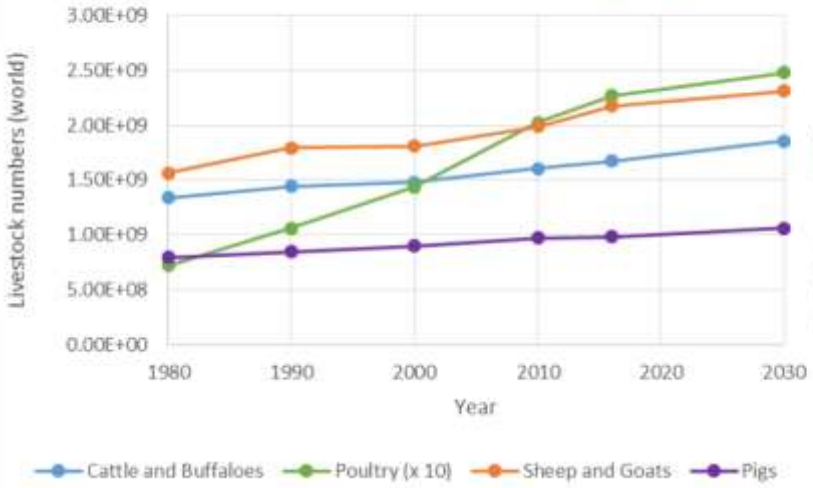
31st January – 1st October

Food revolution

World per capita meat consumption (kg/yr)

- 1980: 30.7
- 2015: 41.3
- ***2030: 45.3***
  → ***75 million tonnes more meat***

(Bangladesh 4 kg/yr – USA 120 kg/yr)



Livestock revolution

Livestock totals:

- 1980: 10.9 billion
- 2016: 27.5 billion
- ***2030: 30 billion*** (175% increase on 1980)

Manure output

Planning storage facilities
Farm nutrient balance calculations

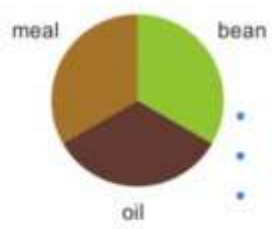
Cattle (540 kg)		Pigs (110 kg)
	Average animal	
40	Manure output (kg/animal/d)	7
0.246	N output(kg/animal/d)	0.04
0.137	P output (kg/animal/d)	0.033
	Average UK herd	
143 (dairy)	Herd size (2016)	450
5.72	Manure output (t/herd/d)	3.15
35.2	N output (kg/herd/d)	18.0
19.6	P output (kg/herd/d)	14.9
	Global 'herd'	
1,474,887,717	Head (2016)	981,797,339
58,995,509	Manure output (t/d)	6,872,581
362,822	N output (t/d)	39,272
202,060	P output (t/d)	32,399

Consider:

large intensive production units

Soy Global Trade Flows (2012)

Total trade flows mMT*	
US to EU	: 1.9
US to China	: 24.2
Brazil to EU	: 16.6
Brazil to China	: 25.9
Brazil to India	: 0.3
Argentina to EU	: 10.8
Arg. to China	: 7.3
Arg. to India	: 0.9



- Nutrient import
- Nutrient concentration
- Nutrient loading

What is science doing?

- Feed conversion efficiency (FCE):

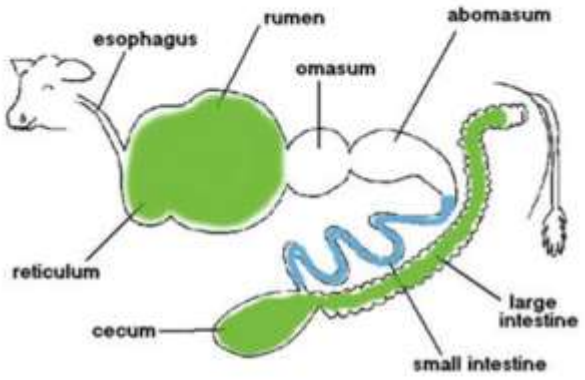
  Live weigh gain / feed intake

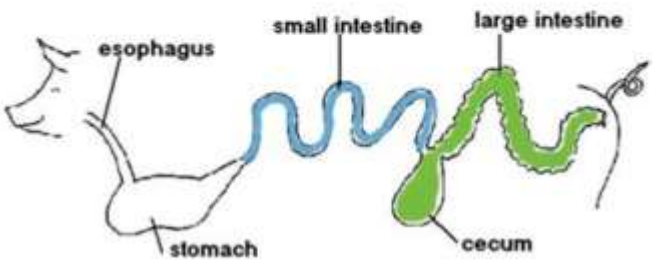
- Improved feed utilisation efficiency on a per unit of production basis:
  - Reduces nutrient content of manure & slurry
  - Reduces polluting potential of manure & slurry
  - Reduces demand for feed nutrients
  - (Improves farmer income)

Manure composition (N, P)

Cattle (540 kg)	(kg/d/1,000 kg LW)	Pigs (110 kg)
74	Manure output	64
0.456	Nitrogen	0.366
0.254	Phosphorus	0.296
Cattle manure contains *ca* 25% more N/unit LW than pig manure	**Why?**	Pig manure contains *ca* 17% more P/unit LW than cattle manure

Comparative digestive physiology





Microbial fermentative digestion

Nutrient absorption

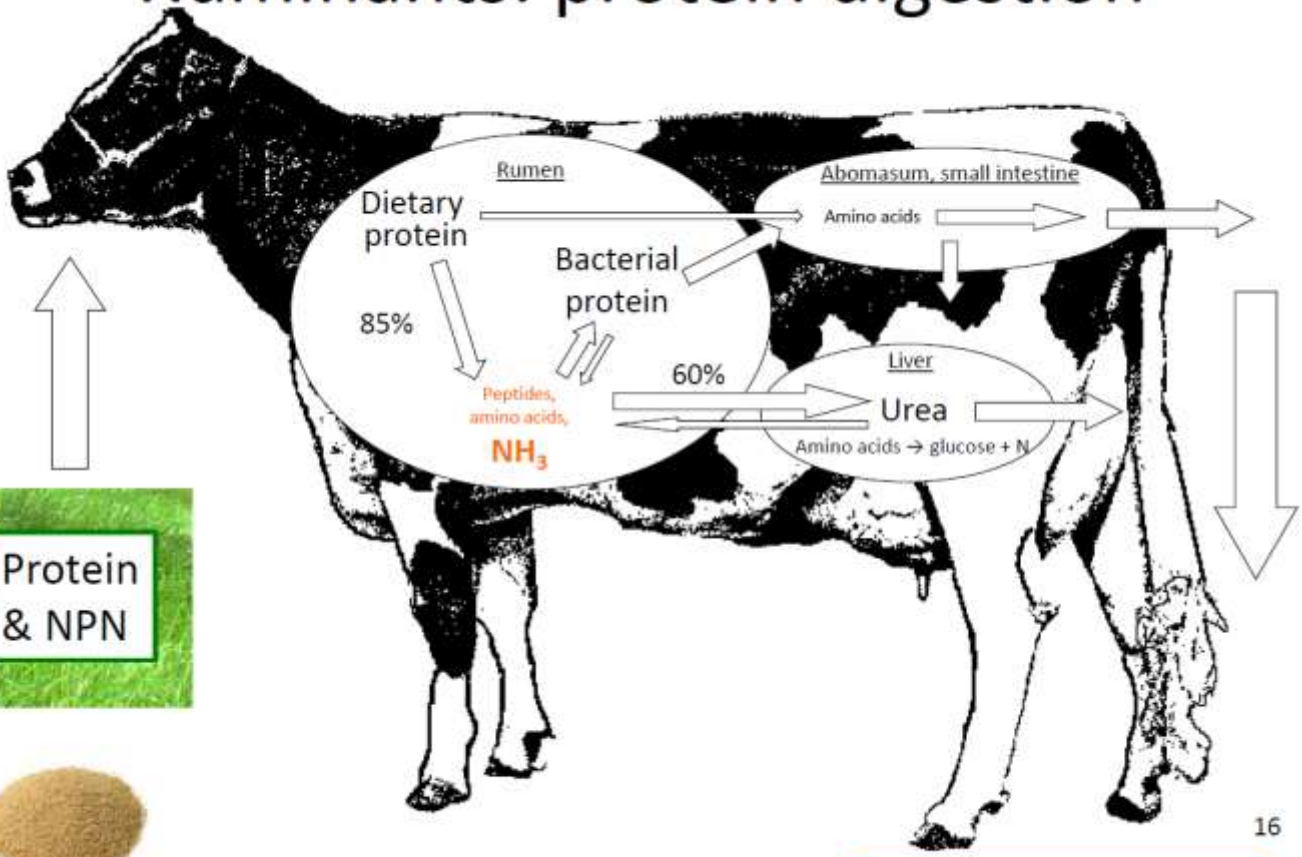
Cattle

- Ruminants
- Four-chambered stomach
- Pre-gastric fermentation

Pigs

- Non-ruminants
- Simple stomach
- Post-gastric fermentation

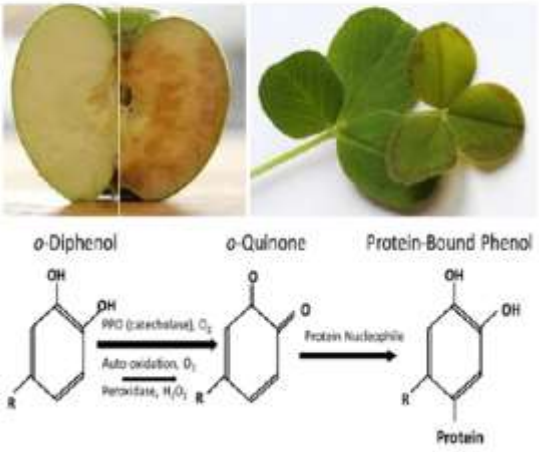
Ruminants: protein digestion



Solutions

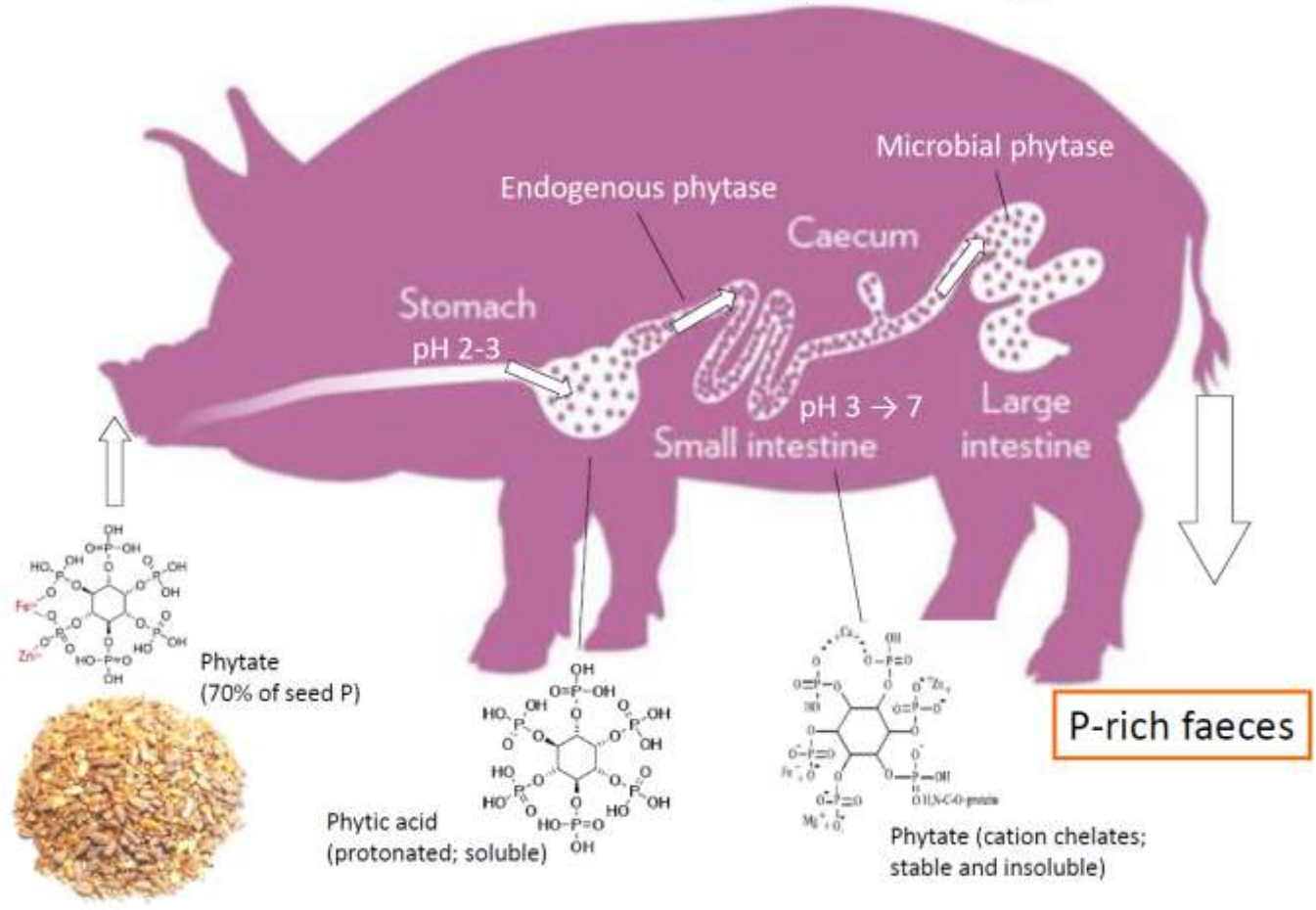
- Stimulate microbial protein synthesis
  - Microbial nutrient requirements (energy)
    - High sugar forages
      - e.g. AberGold, AberDart

- Limit rate of proteolysis
  - Tannins
  - Polyphenol oxidase



Lotus corniculatus (birdsfoot trefoil)

Non-ruminants: phytate digestion



Dietary phosphate supplementation

Phosphate (phosphorite) rock mining

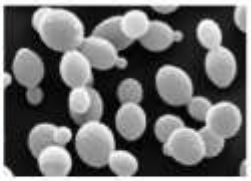
Not sustainable!

Mono- and di-calcium phosphate

Solutions

E. colli

Aspergillus spp.



Sacchoromyces spp.

- Dietary phytase supplementation
  - GM fungi (moulds and yeasts) and bacteria
- GM crops
  - Barley, lucerne, maize, rapeseed, rice and soybeans
- Enviropig

Message

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