The rumen is the engine room of pastoral agriculture

M J Ulyatt

Effect of pasture type on liveweight (kg)

(Johns *et al* 1963)

	1958 trial	1960 trial
Perennial ryegrass	**47**	**44**
Short-rotation ryegrass	**58**	**55**
Per. rye. + white clover	**54**	**57**
S-R rye. + white clover	**63**	**62**
Sig.	**	**

Feeding value

=

f (Feed intake x Nutritive value)

Drivers of f include: physiological state (lactating, growing, etc), activity, environment, behaviour, genotype, pasture management

The comparative feeding value of pasture plants for liveweight gain (relative to perennial ryegrass = 100)

	n	CFV
Perennial ryegrass	16	100
Short-rotation ryegrass	11	148
Italian ryegrass	1	160
Browntop	1	100
White clover	14	192
Red clover	11	131
Lucerne	10	157
Lotus pedunculatus	6	162

Chemical composition of perennial ryegrass, short-rotation ryegrass and white clover (%DM)

	P	S	C
Soluble sugars	14.3	16.9	10.2
Organic acids	9.0	9.2	7.8
Pectin	1.6	1.3	8.8
Ligno-cellulose	32.0	27.2	19.4
Protein	23.8	25.6	27.5
Lipid	6.6	6.1	3.6
Ash	9.7	10.3	9.6
OM digestibility (%)	76.7	77.2	78.9

Performance and digestion parameters from sheep grazed on P, S or C

(Ulyatt 1971)

	P	S	C	Sig
Liveweight gain g/d)	**227**	**270**	**331**	*******
OM intake (g/d)	**1086**	**1123**	**1242**	**ns**
Rumen DM pool (g)	**448**	**413**	**336**	******
Rumen OM retention (h)	**10.4**	**8.7**	**6.3**	******

N digestion in wethers fed 800g OM/d of P, S or C (MacRae & Ulyatt 1974)

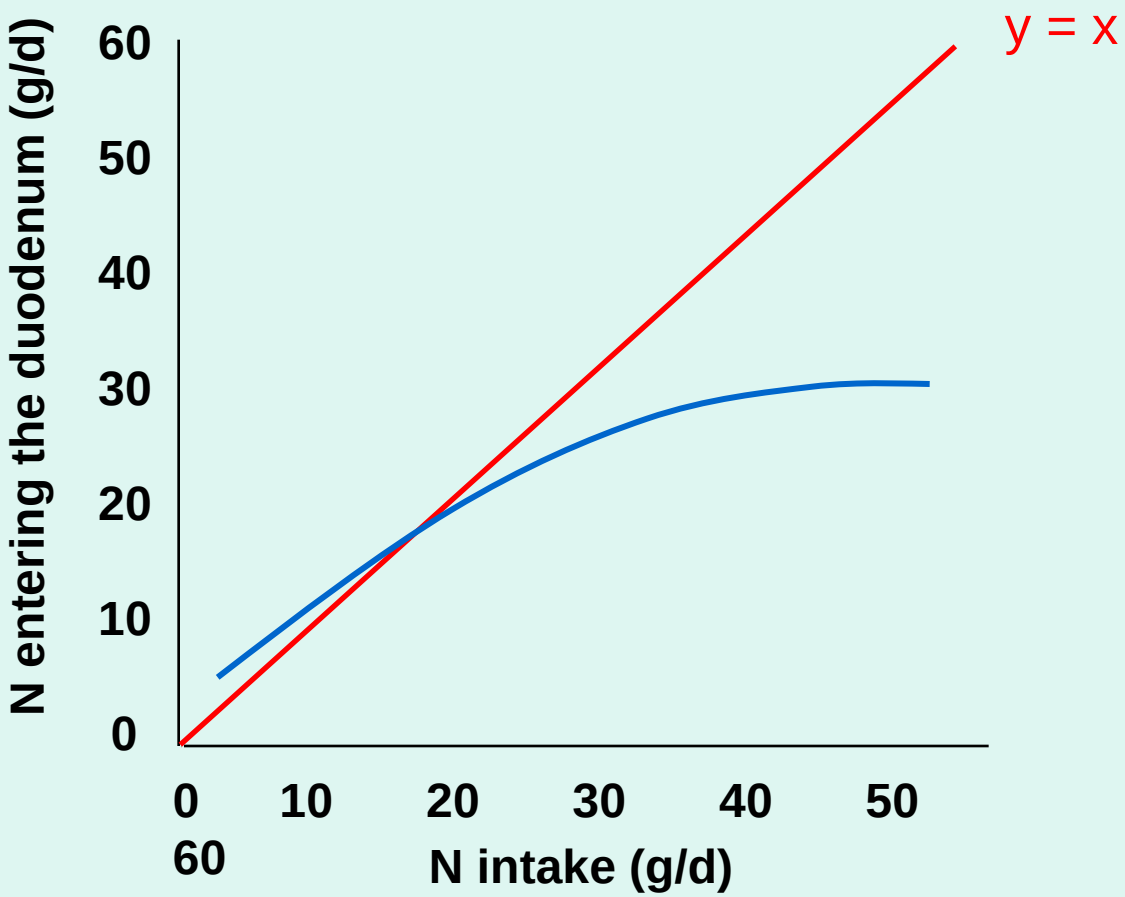
	P	S	C
N intake	**38**	**35**	**35**
N digestibility (%)	**85**	**82**	**82**
% N digestion in:			
Stomachs	**43**	**24**	**32**
Small intestine	**46**	**67**	**59**
% N intake in urine	**72**	**59**	**70**

Indoor digestion measurements extrapolated to field feed intakes

(MacRae & Ulyatt 1974)

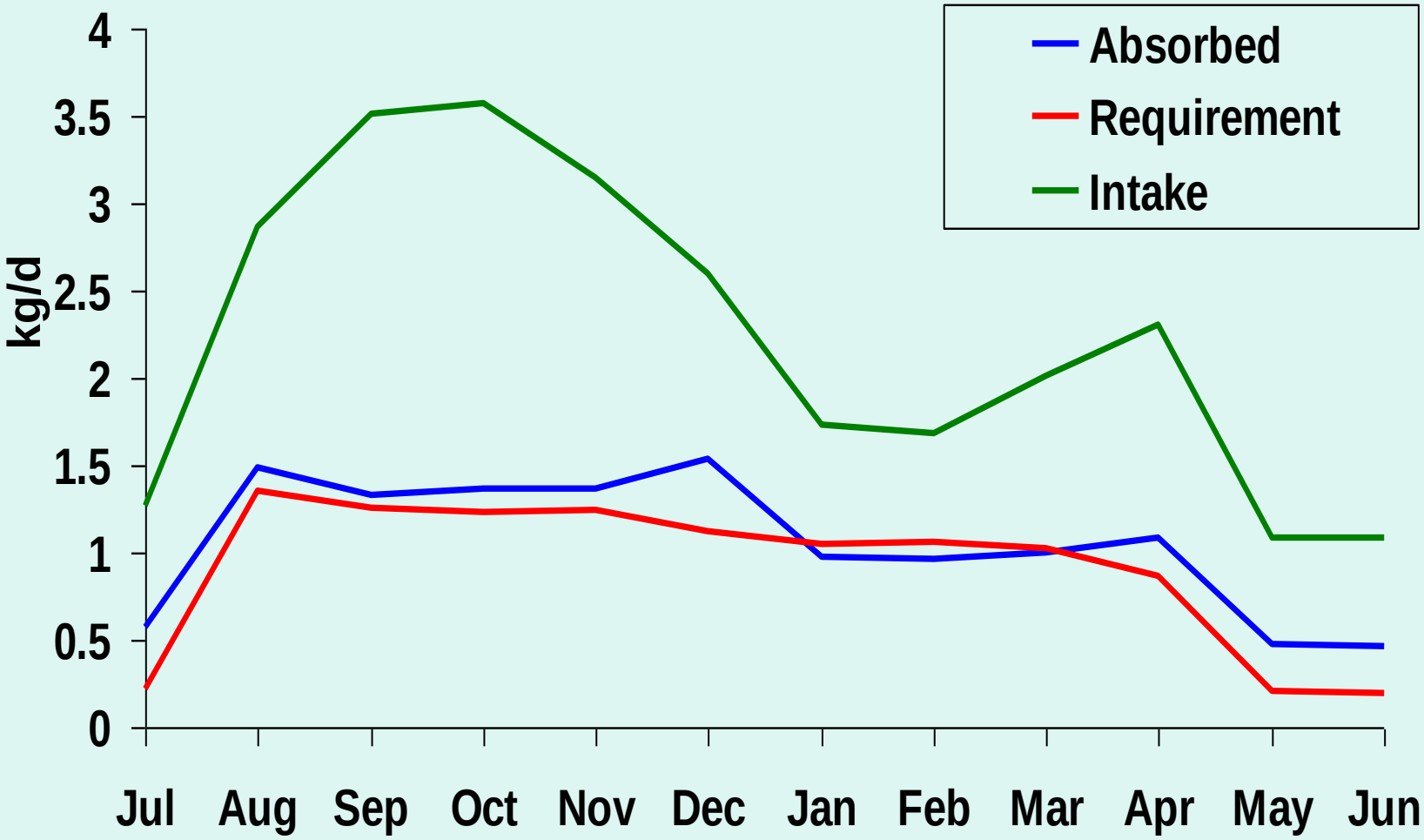
	P	S	C
Liveweight gain (g/d)	227	270	331
VFA absorbed (MJ/d)	10.2	8.6	9.9
Protein absorbed from small intestine (g/d)	119	175	188

Nitrogen digestion in sheep fed fresh herbage



(Ulyatt and Egan, 1979)

Simulation of dairy cow protein supply



How could we improve the efficiency of dietary N utilization in fresh pasture?

- Pasture N is very high, is soluble and is rapidly degraded
- Insufficient energy supply (soluble sugars)
- Also a timing problem between N availability and energy supply at both the rumen and tissue level

- Could we add soluble sugars or starch?
- Could we reduce protein degradability?

N digestion in sheep fed perennial ryegrass, white clover or sainfoin (Ulyatt *et al* 1977)

	Perennial ryegrass	White clover	Sainfoin
N intake (g/d)	**38**	**35**	**34**
% N intake digested in:			
Stomachs	**27**	**18**	**-1**
Intestines	**58**	**64**	**75**

Effects of CT on amino acid transactions in the small intestine of sheep fed *Lotus corniculatus*

(ex Waghorn)

	CT	CT+ PEG	
N intake (g/d)	38	38	
CT content (% DM)	2.2	2.2	
Rumen NH_3-N (µg/ml)	302	415	***
EAA entering SI (g/d)	96	64	**
App. EAA absorption (g/d)	59	36	**
EAA digestibility in SI (%)	69	65	NS

Effects of CT on amino acid transactions in the small intestine of sheep fed *Lotus pedunculatus* (ex Waghorn)

	CT	CT + PEG	
N intake (g/d)	42	48	
CT content (% DM)	5.5	5.5	
Rumen NH_3-N (µg/ml)	175	458	***
EAA entering SI (g/d)	121	106	**
App. EAA absorption (g/d)	81	84	ns
EAA digestibility in SI (%)	66	79	*

The physical properties of feeds

Size of feed particles escaping the rumen of sheep fed lucerne hay (% particulate DM retained on sieve) (Ulyatt 1983)

Seive (mm)	Rumen	Abomasum
4.0	16	0
2.0	10	0
1.0	16	11
0.5	19	30
0.25	15	27
<0.25	27	33

Particle size distribution in the abomasa of sheep (% particulate DM retained on sieve) (Ulyatt *et al* 1984)

	Digestibility of DM (%)	Sieve size (mm)			
		4	2	1	<1
Perennial rye.	**78**	**1**	**1**	**1**	**97**
White clover	**79**	**0**	**1**	**5**	**93**
Red clover	**78**	**0**	**1**	**4**	**95**
Lucerne	**72**	**1**	**2**	**7**	**90**
Lucerne hay	**65**	**0**	**1**	**3**	**96**
Meadow hay	**60**	**1**	**1**	**5**	**93**

Effect of diet on the reduction of particle size during eating (Ulyatt *et al* 1984)

	Perennial ryegrass	Red clover	Lucerne	Meadow hay	Lucerne hay
DM intake (g/d)	861	918	952	943	946
DM digestibility (%)	78	78	72	60	54
Soluble DM released by eating (% intake)	37	38	32	20	23
Chews/g DMI during eating	37	13	11	12	19
% LP reduced to <1 mm by eating	49	52	45	35	37

Effect of diet on the reduction of particle size during rumination (Ulyatt *et al* 1984)

	Perennial ryegrass	Red clover	Lucerne	Lucerne hay	Meadow hay
DM digestibility (%)	**78**	**78**	**72**	**60**	**54**
Rumination time (min/d)	**540**	**436**	**317**	**570**	**547**
Chews/g DM during rumination	**31**	**23**	**21**	**20**	**19**
% LP reduced to <1 mm by rumination	**42**	**39**	**63**	**60**	**65**

The movement of DM through the rumen in sheep fed various diets (Ulyatt *et al* 1984)

	Perennial ryegrass	Red clover	Lucerne	Meadow hay	Lucerne hay
Rumen DM pool (g)	**387**	**341**	**264**	**530**	**554**
Fractional flows (d^{-1}):					
Digestion	**1.5**	**1.7**	**2.0**	**0.9**	**0.6**
Rumination	**4.9**	**5.9**	**6.2**	**4.8**	**4.4**
Passage	**1.0**	**1.1**	**1.6**	**0.9**	**1.1**

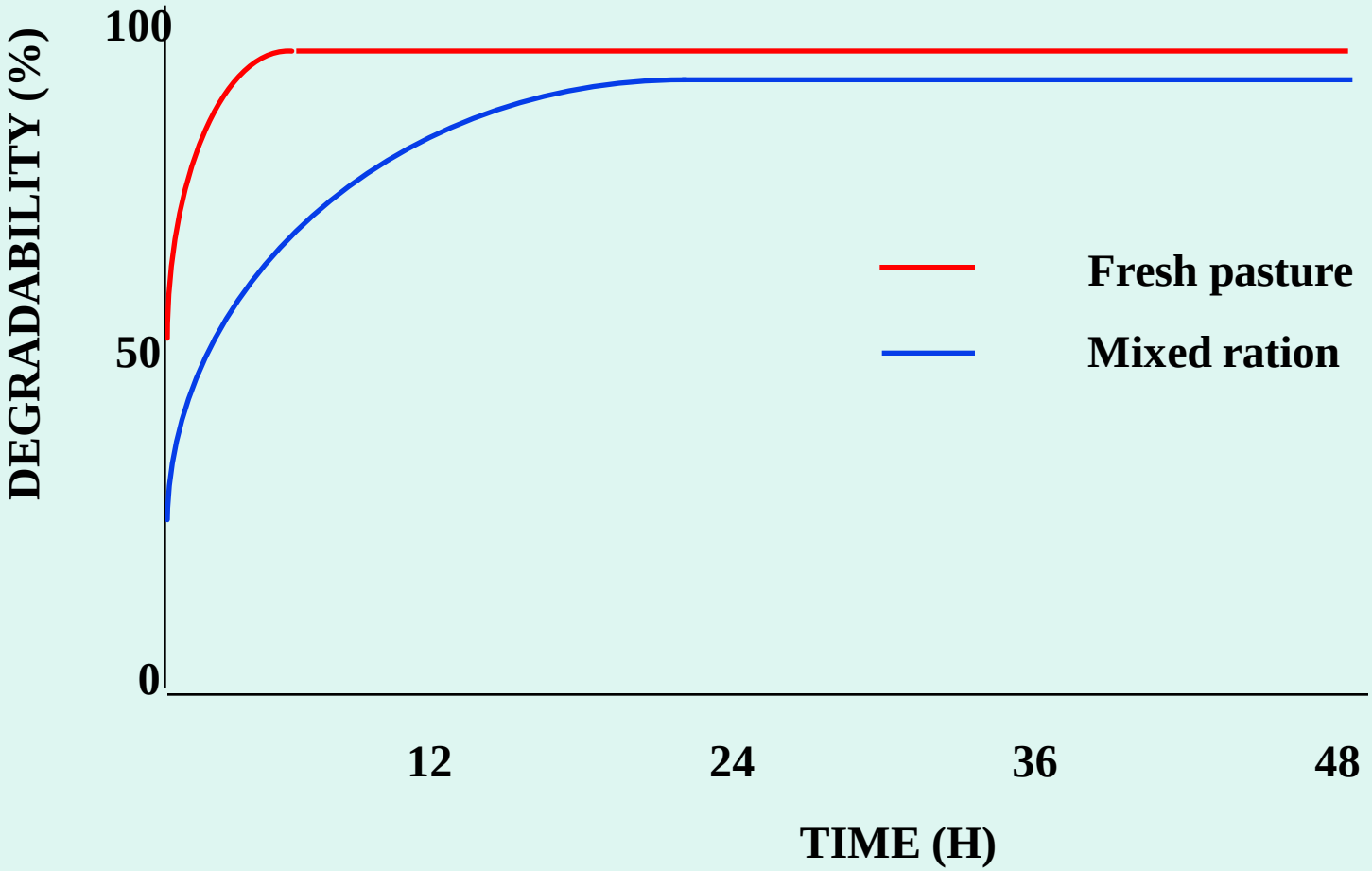
Clearance of the reticulo-rumen

- Particle size reduction dominated by chewing
- C.EAT: prepares for swallowing, releases solubles, exposes tissues to microbes
- C.RUM: reduces PS of refractory material for clearance
- Particles must be <1-2 mm to pass from the rumen; but, only increases probability
- Reticular contractions drive passage; amplitude rather than frequency

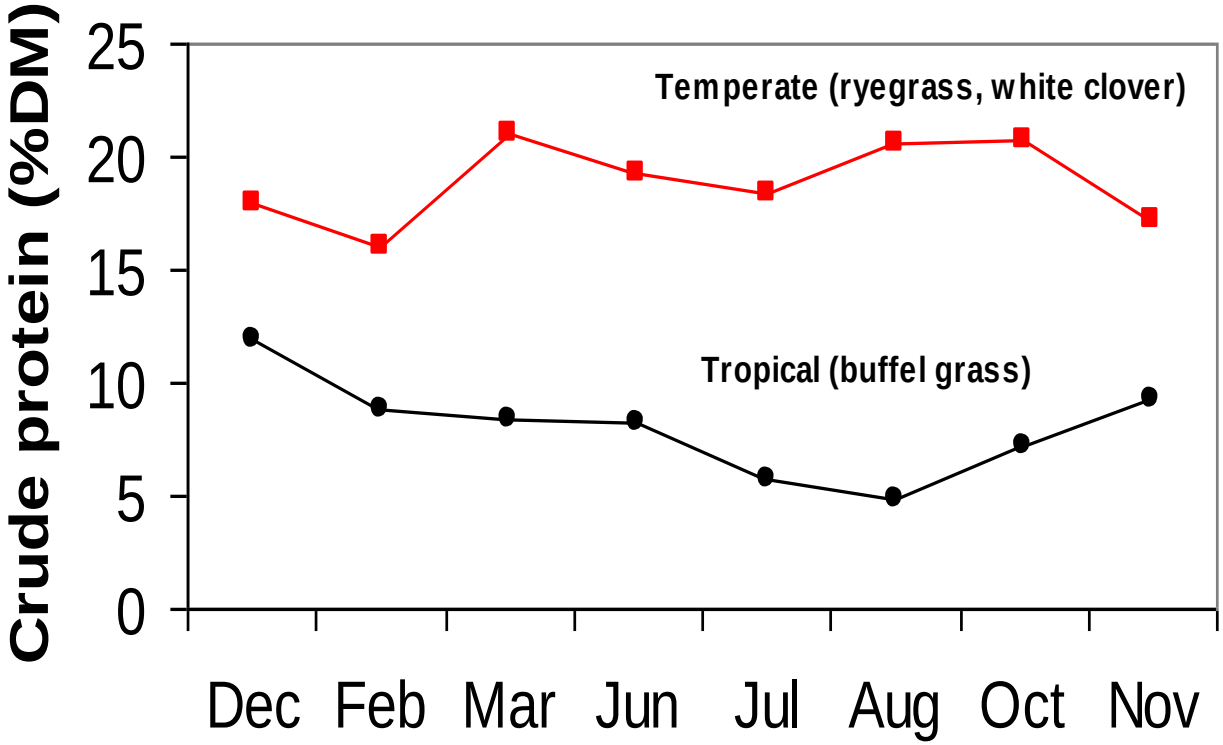

Bulk!

Protein degradability of diets

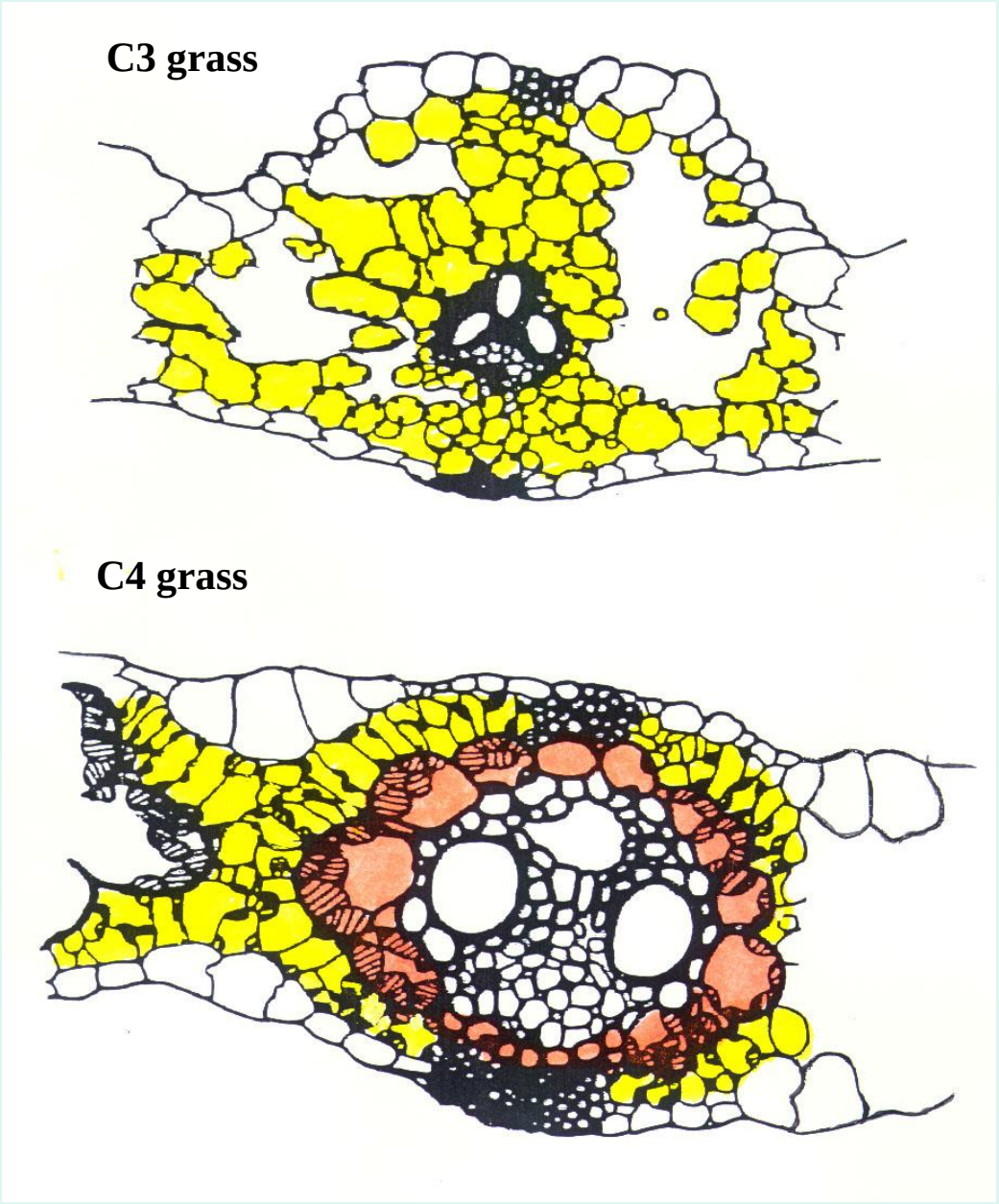
(ex McNabb)



Seasonal variation in the protein content of temperate and tropical pastures
(Ulyatt and McNabb 1999)



CROSS SECTIONS OF GRASS LEAF VEINS



(Wilson, 1993)

Comparison of grass tissues (%DM)
(Wilson 1993)

		Mesophyll	PBS
C3	Blade	66	5
	Stem	2	0
C4	Blade	31	24
	Stem	2	0

Distribution of Rubisco in grass tissues (Ulyatt & McNabb 1999)

Grass type	C3	C4
Soluble N (% DM)	52	35
% soluble protein as Rubisco	25 - 60	8 - 23
% Rubisco in mesophyll	100	0
% Rubisco in parenchyma bundle sheath	0	100

Understand the rumen because it is the engine room of pastoral agriculture

Some physical factors that can affect feeding value

- Plant tissue structure
- Resistance to chewing
  - Strength/elasticity of sclerenchyma fibre
- Bulk density
- Heat denaturation
- Degradability