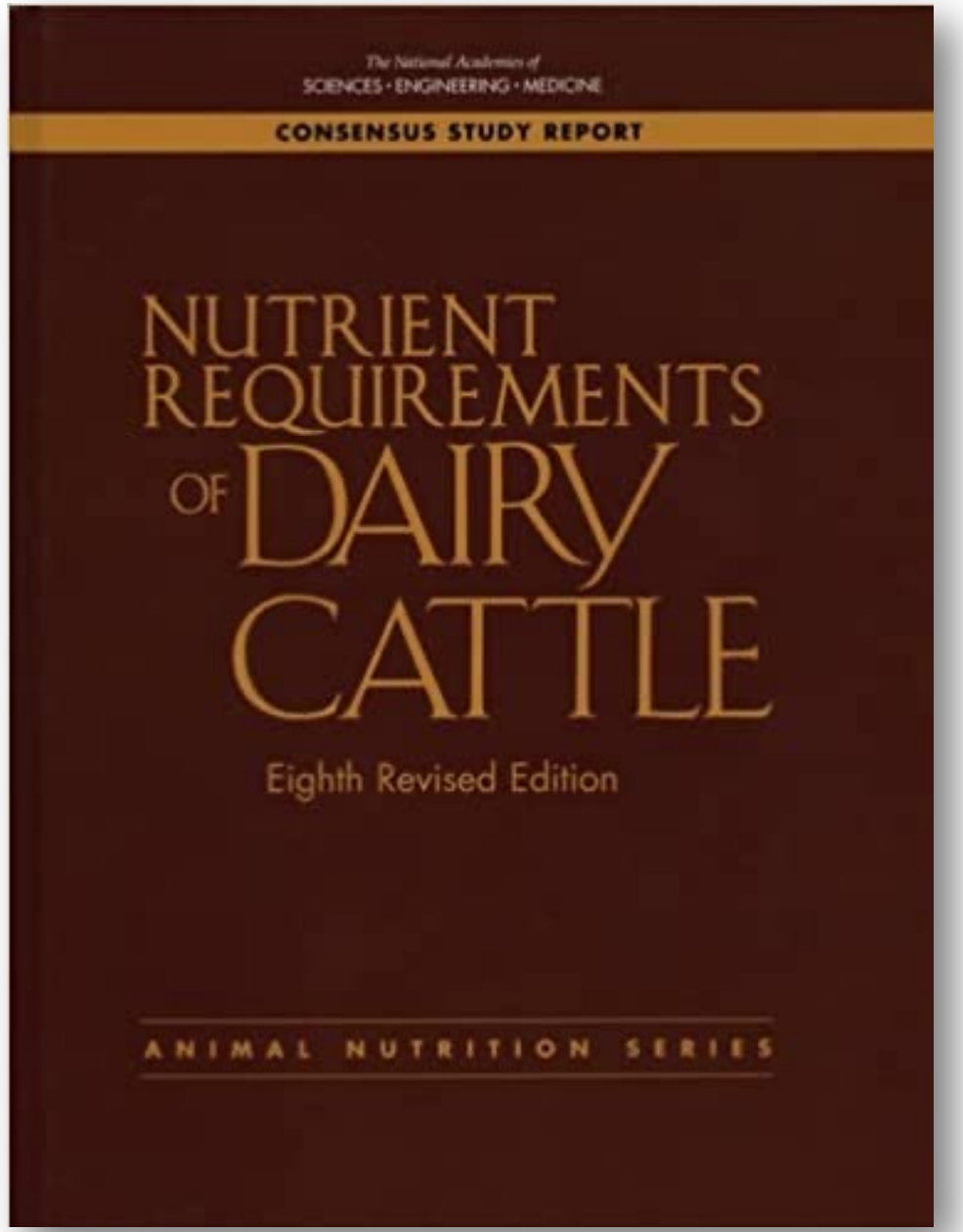
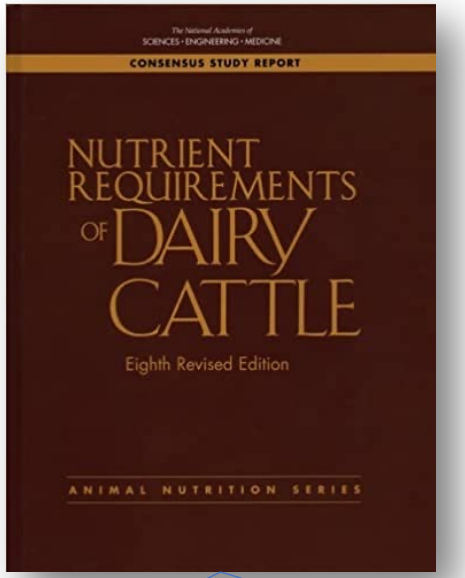

The National Academies of
SCIENCES • ENGINEERING • MEDICINE
CONSENSUS STUDY REPORT
NUTRIENT REQUIREMENTS OF DAIRY CATTLE
Eighth Revised Edition
ANIMAL NUTRITION SERIES



A.

Summary[1]

Since the publication of the first booklet on animal nutrient requirements in 1945 (the dairy section consisted of 21 pages), the National Research Council's series on the *Nutrient Requirements of Dairy Cattle* has become an essential tool for students, teachers, researchers, and the dairy industry. The seventh revised edition was more than 380 pages. The information, equations, and, more recently, the software included in these publications have helped the dairy industry improve the efficiency of nutrient utilization, reduce the environmental impact of milk production, and improve the health of dairy cows. The updates to this publication generally reflect incremental

B.

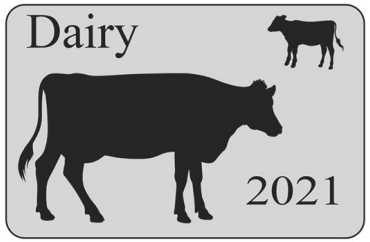
TABLE 15-1 Nutrient Composition and Variability of Some Feedstuffs Commonly Fed to Dairy Cattle (all values on a dry basis)

Entry No.	Feed Name/Description	International Feed No.	TDN-1X %	TDN Equation Class	PAF	DE-1X Mcal/kg	ME-3X Mcal/kg	NEL-3X Mcal/kg	NEL-4X Mcal/kg	NEM-3X Mcal/kg	NEG-3X Mcal/kg	DM %	CP %	NDICP %	ADICP %	Ether Extract %	NDF %	ADF %	Lignin %	Ash %
	ALFALFA	Also see LEGUMES, FORAGE																		
	Medicago sativa																			
1	Meal, 17% CP	1-00-023	56.4	Forage	1.00	2.60	1.96	1.19	1.11	1.27	0.70	90.3	19.2	3.1	2.4	2.5	41.6	32.8	7.6	11.0
		N										222	221	3	70	54	221	220	70	84
		SD										1.4	3.3	0.3	0.1	0.6	7.1	5.1	1.2	2.3
	ALMOND																			
2	Hulls	4-00-359	58.4	Conc	1.00	2.53	1.89	1.14	1.07	1.22	0.65	86.9	6.5	2.3	1.8	2.9	36.8	28.7	14.9	6.1
		N										23	32	4	3	23	30	30	11	16
		SD										5.6	2.5	0.3	0.4	2.0	11.2	8.5	3.0	0.5
	APPLE																			
3	Pomace, wet	4-25-450	57.1	Conc	1.00	2.48	1.86	1.12	1.06	1.18	0.62	35.9	7.7	3.7	3.1	5.0	52.5	43.2	15.4	2.6
		N										65	65	3	4	22	65	65	5	16
		SD										29.4	3.8	0.9	0.7	1.9	9.5	6.6	2.6	1.1

C.

FIGURE 1

NASEM Dairy 8



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NASEM Dairy 8

Committee on Nutrition Requirements of Dairy Cattle

Richard A. Erdman – (Co-Chair), University of Maryland, College Park
William P. Weiss – (Co-Chair), The Ohio State university
Michael Allen, Michigan State University
Louis Armentano, University of Wisconsin – Madison
James Drackley, University of Illinois at Urbana-Champaign
Jeffrey Firkins, The Ohio State University
Mary Beth Hall, USDA US Dairy Forage Research Center
Mark Hanigan, Virginia Polytechnic Institute and State
Ermias Kebreab, University of California, Davis
Paul Kononoff, University of Nebraska-Lincoln
Hélène Lapierre, Agriculture & Agri-Food Canada
Michael VandeHaar, Michigan State University

Nutrient Requirements of Dairy Cattle
Eight revised redition
V8 R2021.11.29

Software Designer and Engineer
Abbas Ahmadi, PhD. University of California Davis

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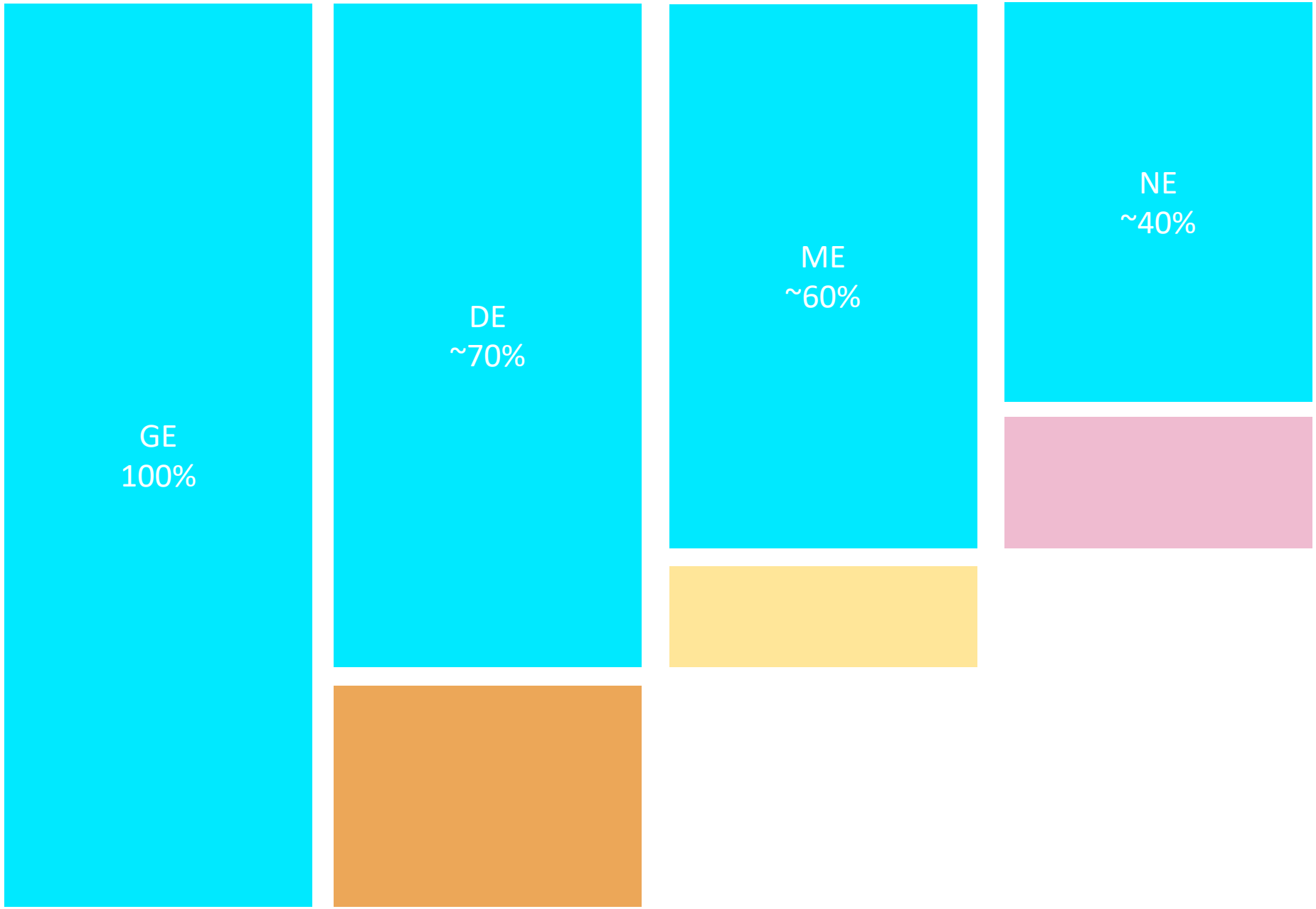
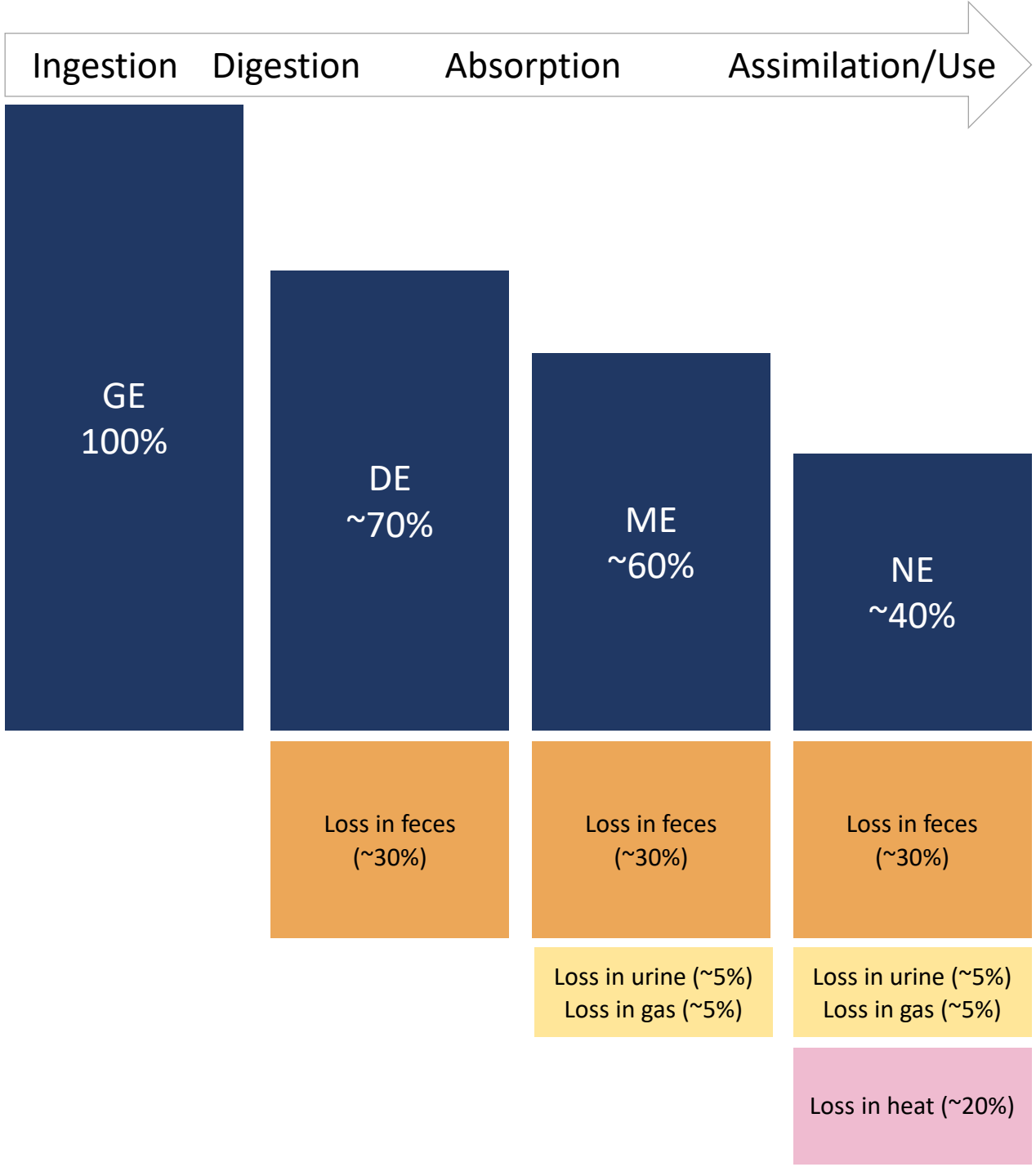
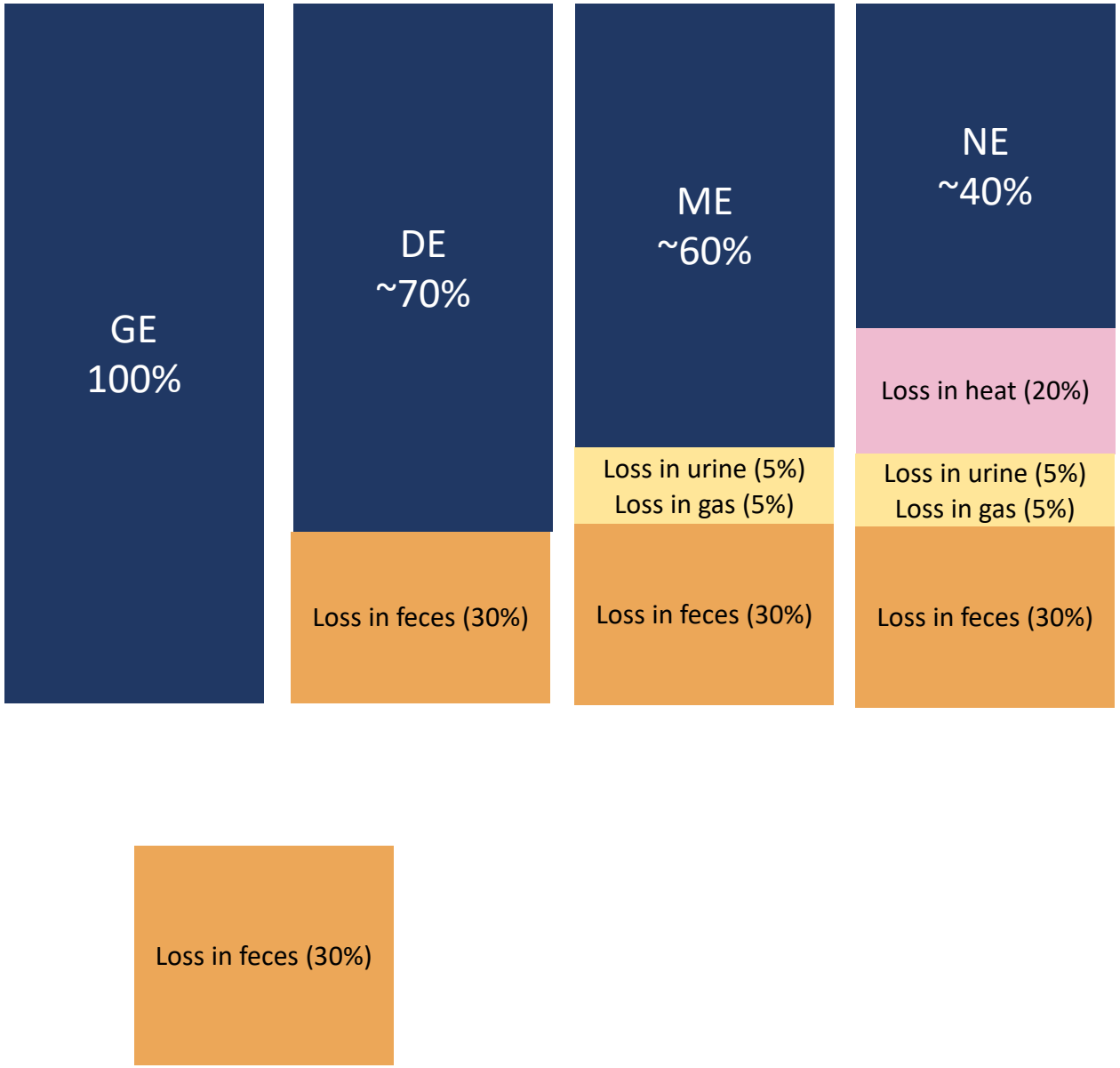
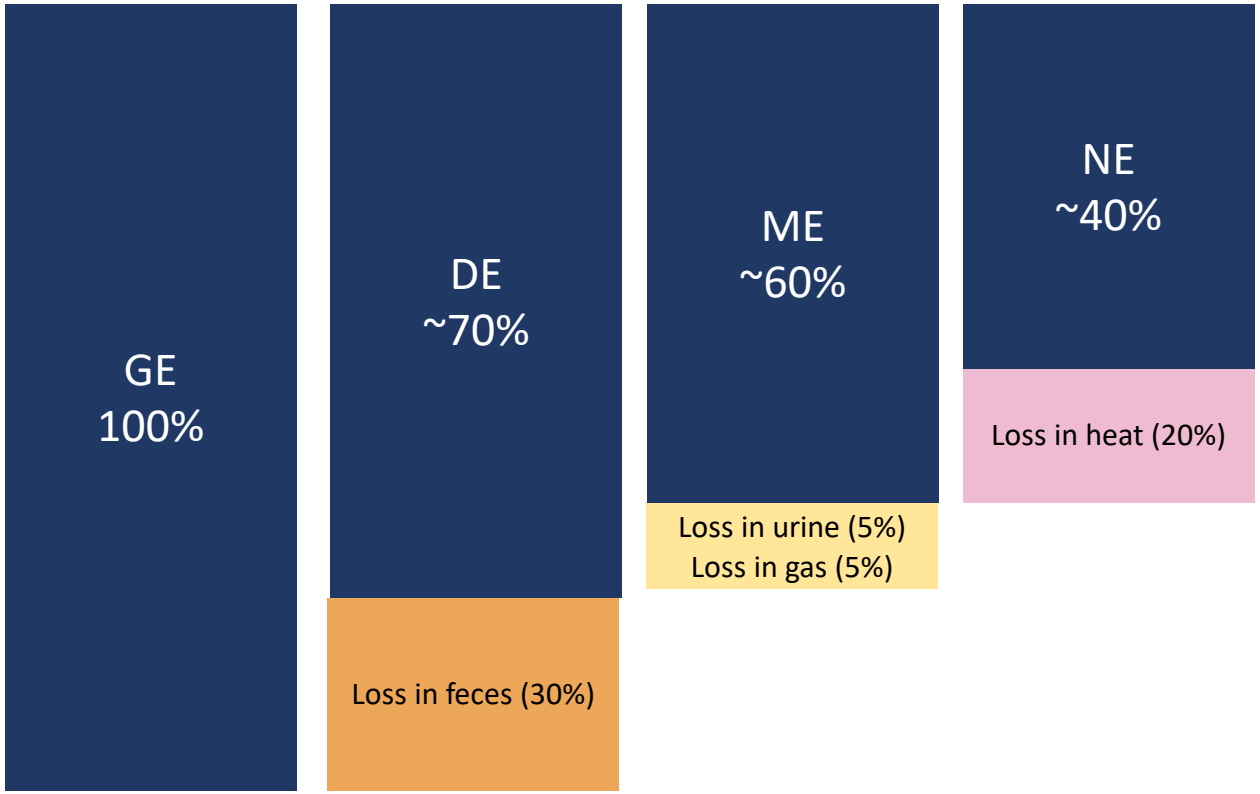
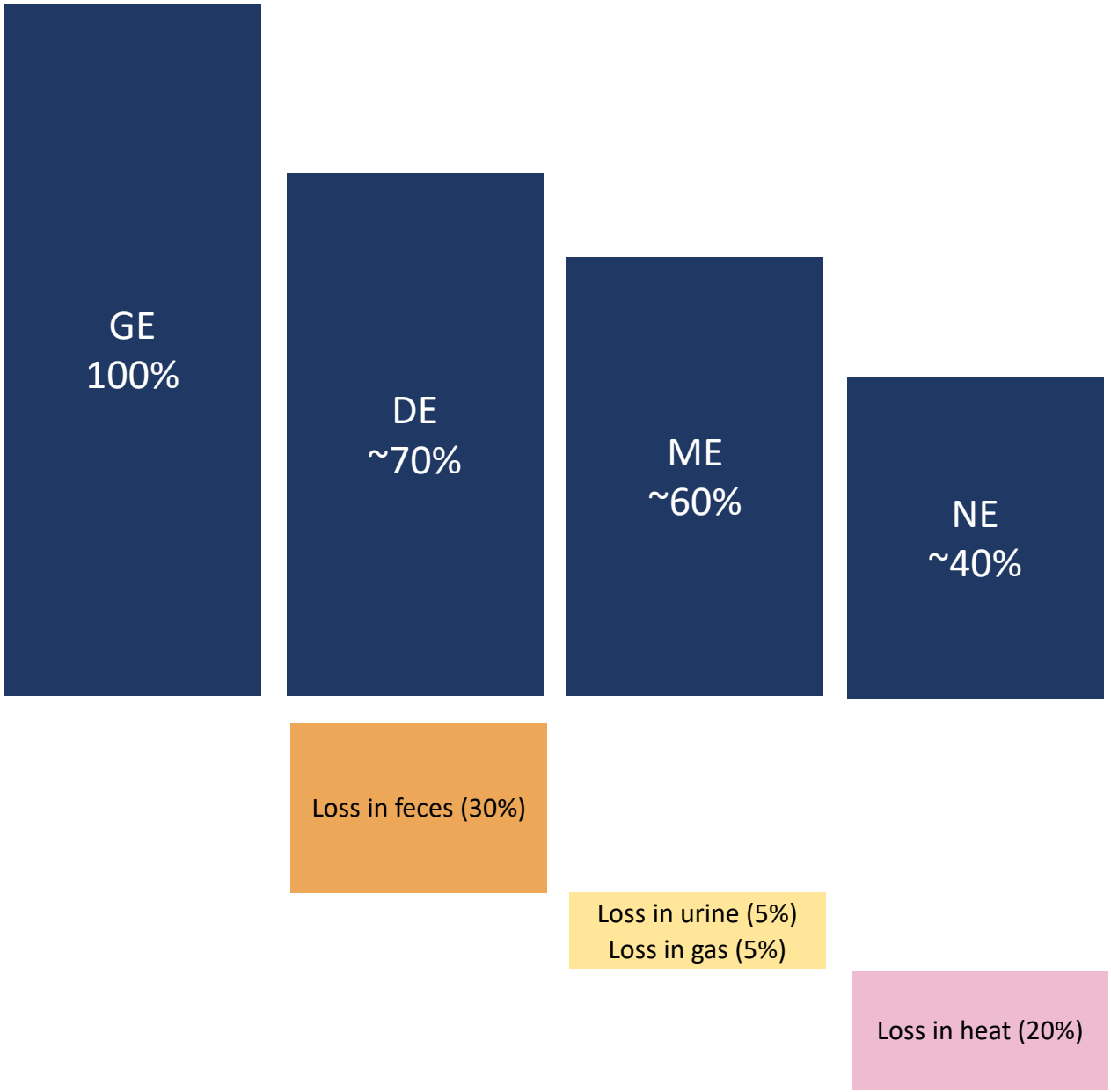
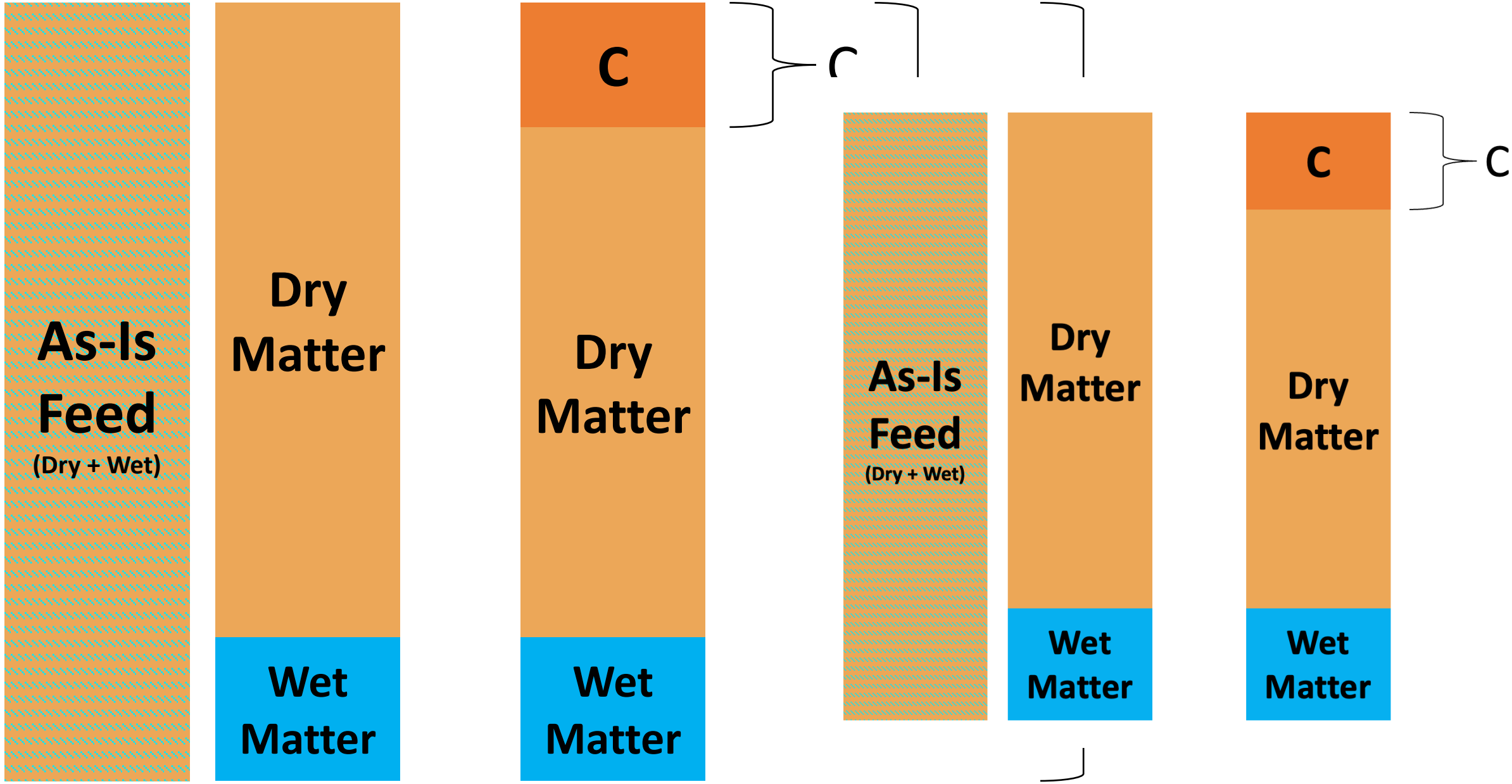

GE
100%
DE
~70%
ME
~60%
NE
~40%

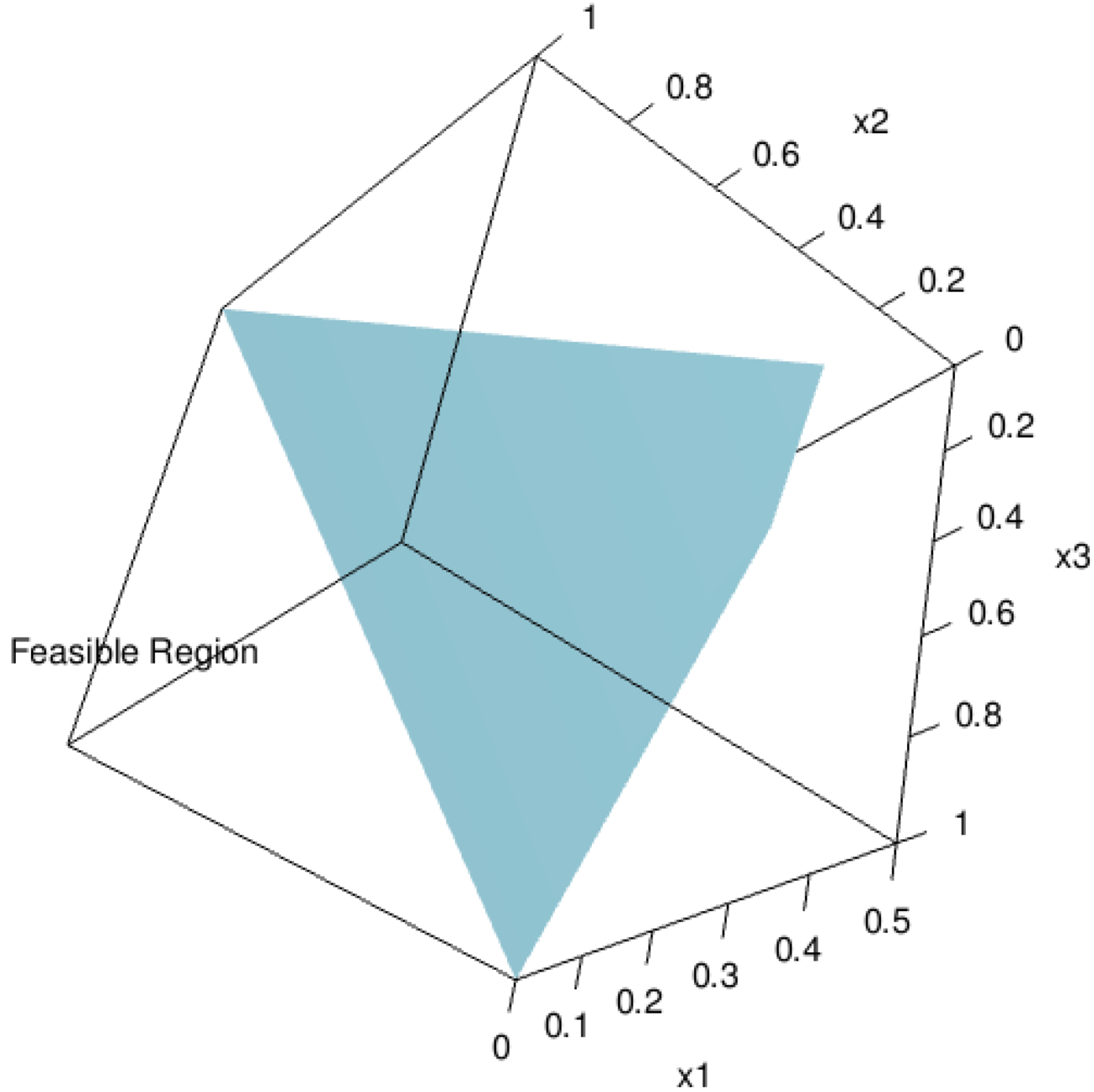

Ingestion
Digestion
Absorption
Assimilation/Use
GE
100%
DE
~70%
ME
~60%
NE
~40%
Loss in feces
(~30%)
Loss in feces
(~30%)
Loss in feces
(~30%)
Loss in urine (~5%)
Loss in gas (~5%)
Loss in urine (~5%)
Loss in gas (~5%)
Loss in heat (~20%)

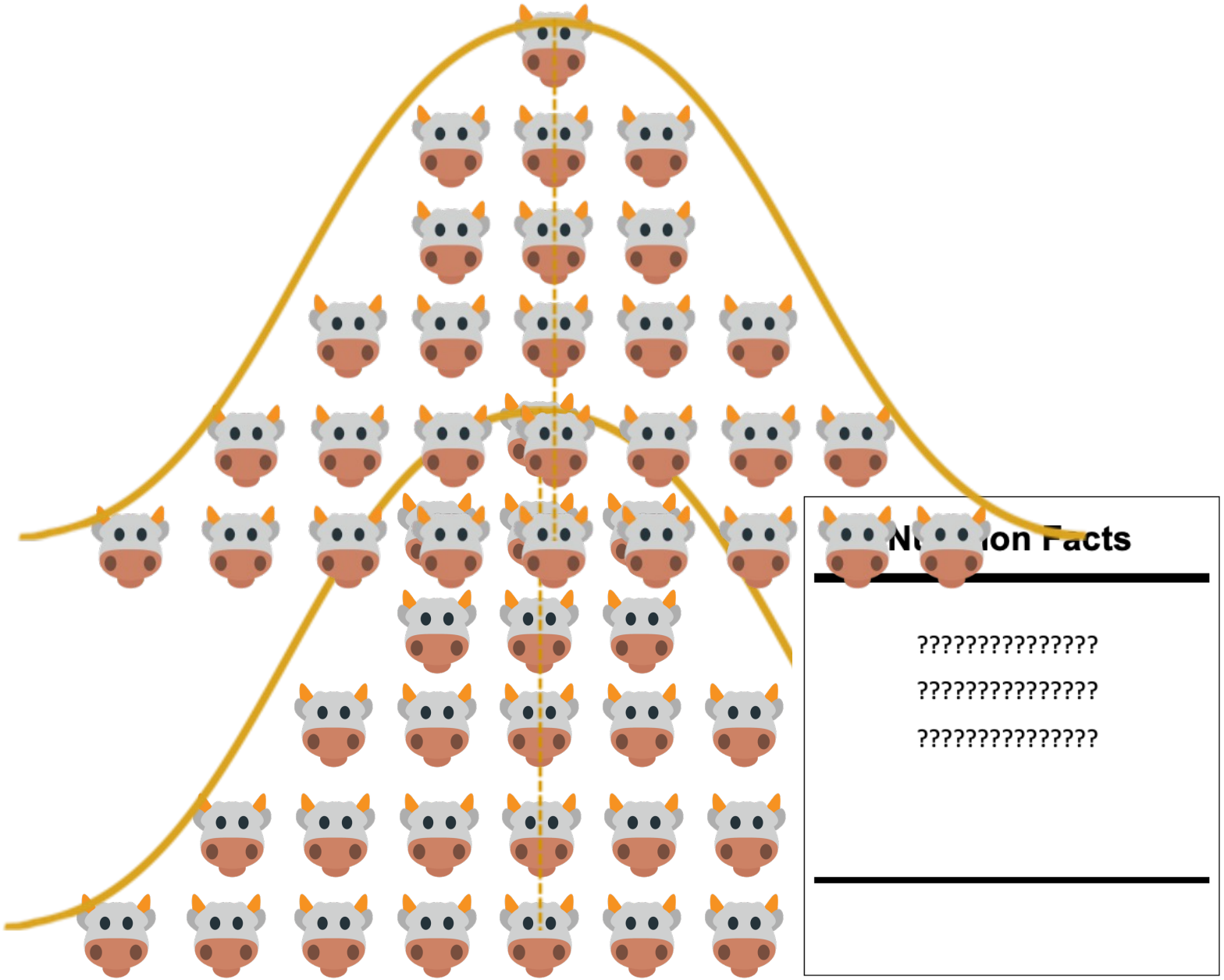

GE
100%
DE
~70%
Loss in feces (30%)
ME
~60%
Loss in urine (5%)
Loss in gas (5%)
Loss in feces (30%)
NE
~40%
Loss in heat (20%)
Loss in urine (5%)
Loss in gas (5%)
Loss in feces (30%)
Loss in feces (30%)


GE
100%
DE
~70%
Loss in feces (30%)
ME
~60%
Loss in urine (5%)
Loss in gas (5%)
NE
~40%
Loss in heat (20%)


GE
100%
DE
~70%
ME
~60%
NE
~40%
Loss in feces (30%)
Loss in urine (5%)
Loss in gas (5%)
Loss in heat (20%)


As-Is Feed
(Dry + Wet)
Dry Matter
Wet Matter
C
Dry Matter
Wet Matter
C
As-Is Feed
(Dry + Wet)
Dry Matter
Wet Matter
C
Dry Matter
Wet Matter
C


1
0.8
0.6
0.4
0.2
x2
0
0.2
0.4
0.6
0.8
1
x3
Feasible Region
0
0.1
0.2
0.3
0.4
0.5
x1



Nutrition Facts

??????????????

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Nutrition Facts

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I can’t
read

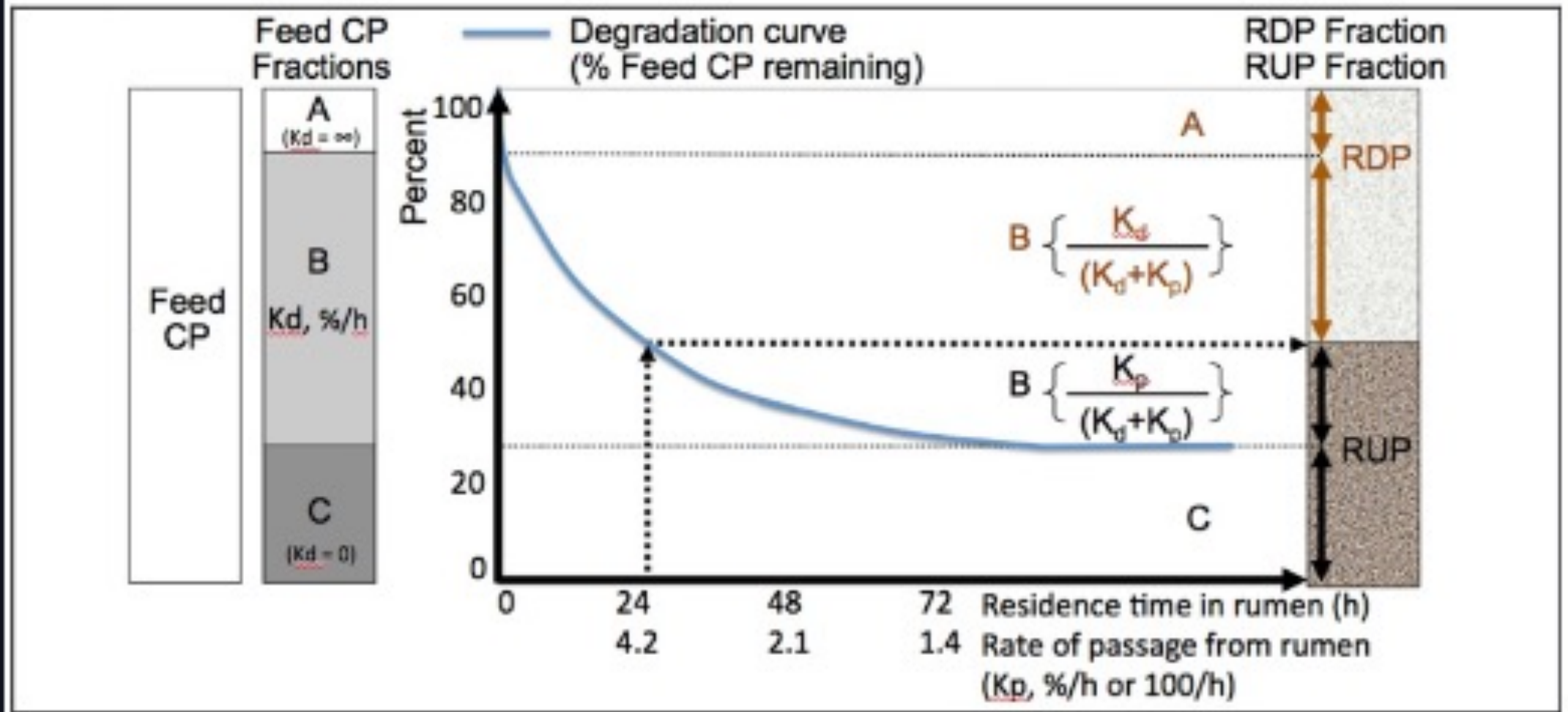
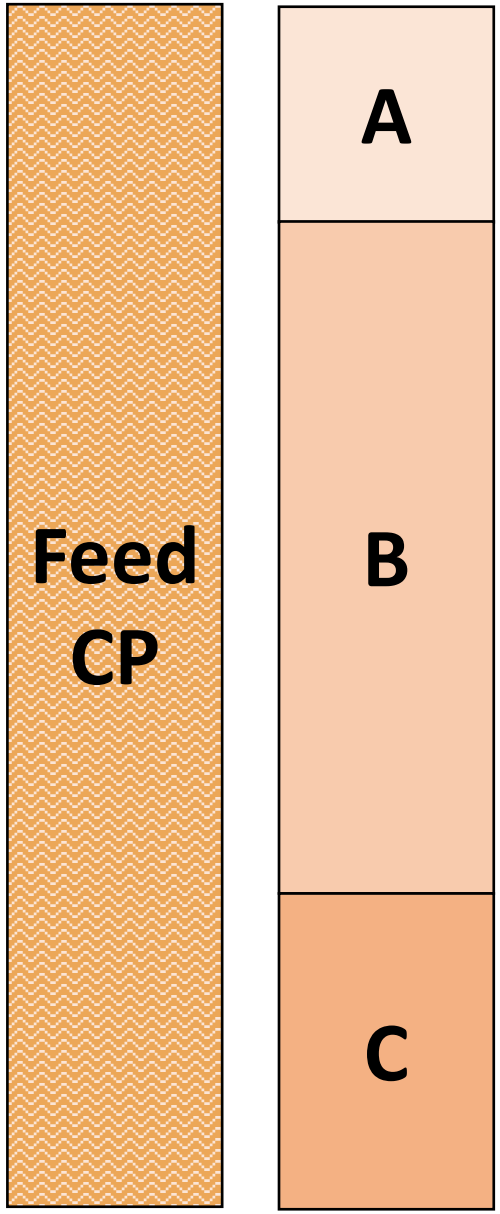


Figure 2: Degradable versus Degraded CP in the rumen.

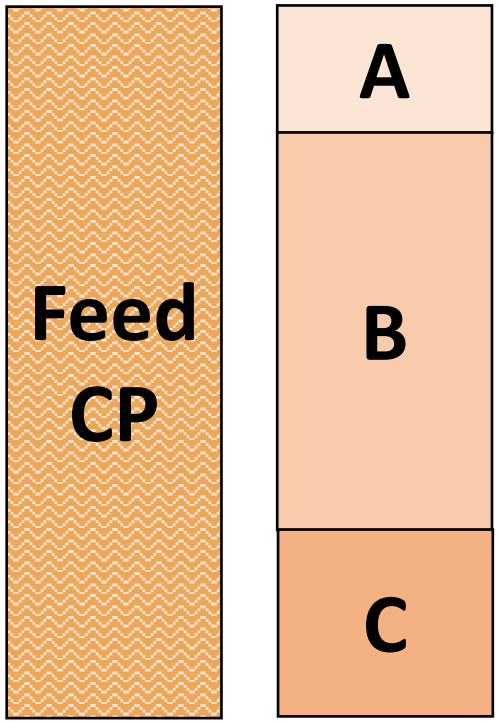


6.4 kg A passage / 100 kg A fraction

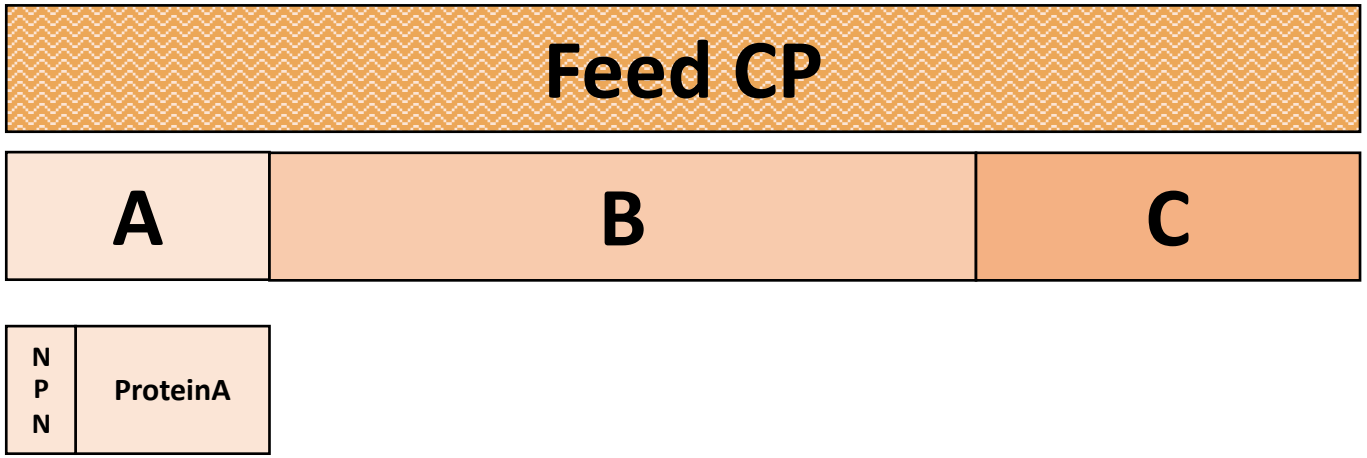
Absorbs or passes quickly

P

	Absorbed	Passes
A	93.6	6.4
B	$\frac{Kd_c}{Kd_c + Kp_c}$	$\frac{Kp_c}{Kd_c + Kp_c}$
C	0.0	100.0



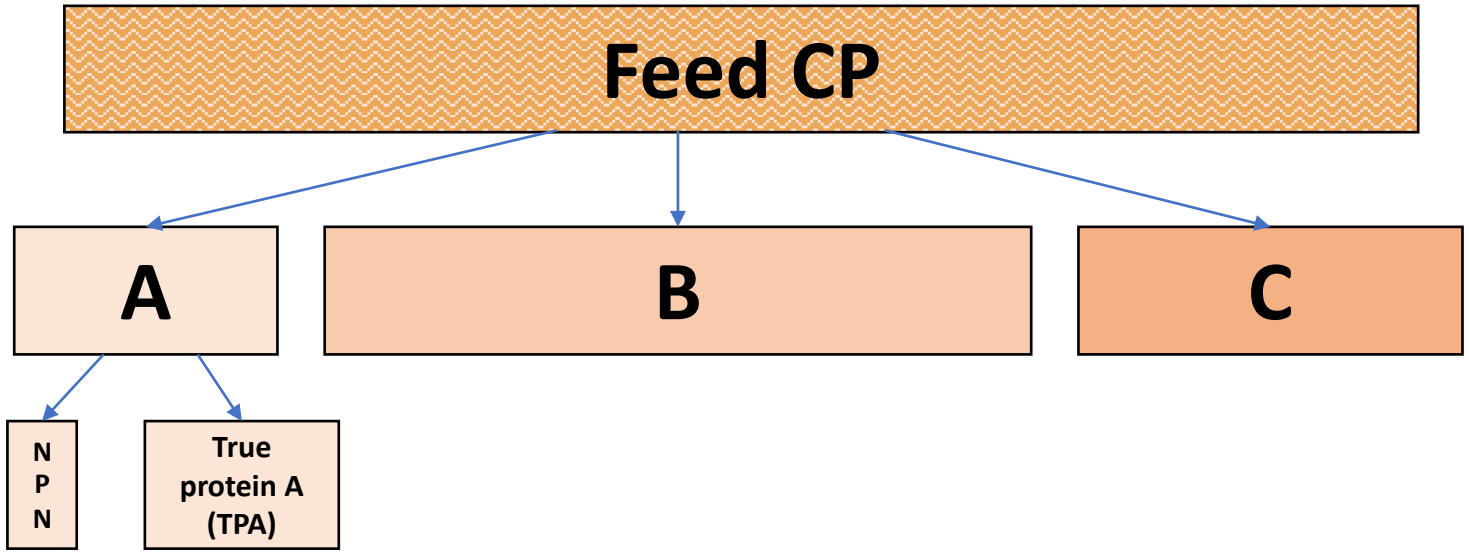
	Absorbed (RDP)	Passes (RUP)
Absorbs or passes instantaneously Fixed percentages absorbed vs. passing	93.6	6.4
Competitive absorption and passage	$\frac{Kd_c}{Kd_c + Kp_c}$	$\frac{Kp_c}{Kd_c + Kp_c}$
None absorbed, all passes	0.0	100.0



Absorbed (RDP)	**NPN** + 93.6***ProteinA**	$\frac{Kd_c}{Kd_c+Kp_c}$ * **B**	0.0 * **C**
Passes (RUP)	6.4***ProteinA**	$\frac{Kp_c}{Kd_c+Kp_c}$ * **B**	100.0 * **C**
	Absorbs or passes instantaneously. Fixed percentages of **A** absorbed vs. passing	Competitive absorption and passage	None absorbed, all passes

f$Fd_RUPIn <- (f$Fd_CPAIn-f$Fd_NPNCPIn) * fCPAdu

Partitioning of CP into A, B, C, and sub-fractions



Kinetic parameters

Kp are specific to the feed type t

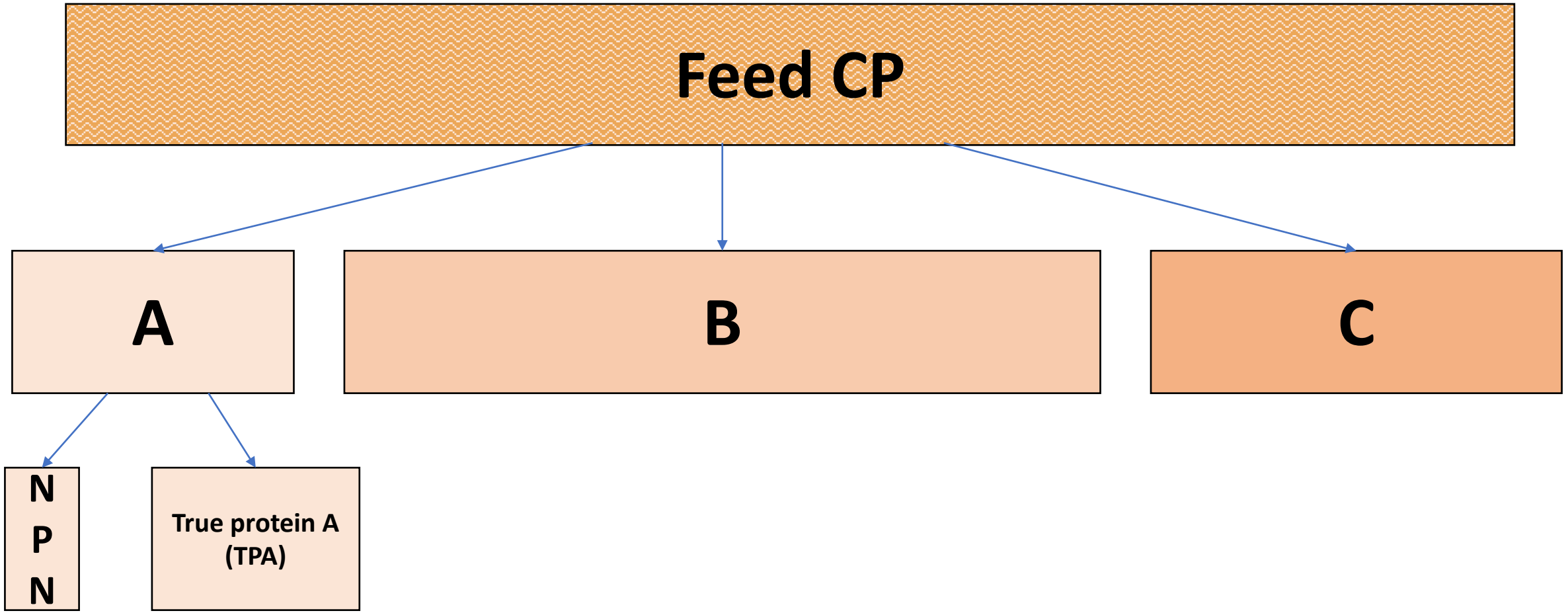
$$Kp_{forage} = 4.87$$

$$Kp_{concentrate} = 5.28$$

Kd are specific to each feed ingredient i (see Feed Tables, NASEM). For example, there is a Kd for "Corn Silage, Typical."

Calculation of RDP and RUP from A, B, C, and sub-fractions and kinetic parameters

Absorbed (RDP)	RDP from A **= NPN** + 93.6***TPA**	RDP from B $= \frac{Kd_i}{Kd_i+Kp_t}$ ***** **B**	RDP from C = 0.0 ***** **C**	RDP total = (RDP from A) + (RDP from B)
Passes (RUP)	RUP from A = 6.4***TPA**	RUP from B $= \frac{Kp_i}{Kd_i+Kp_t}$ ***** **B**	RUP from C = 100.0 ***** **C**	RUP total = (RUP from A) + (RUP from B) + (RUP from C)
Notes	Absorbs or passes instantaneously. Fixed percentages of **A** absorbed vs. passing	Competitive absorption and passage of **B** fraction.	None absorbed, all **C** passes	It should always be true that: CP = (RDP total) + (RUP total) and CP = A + B + C


Feed CP
A
B
C
N
P
N
True protein A
(TPA)

Calculation of RDP and RUP from A, B, C, and sub-fractions and kinetic parameters

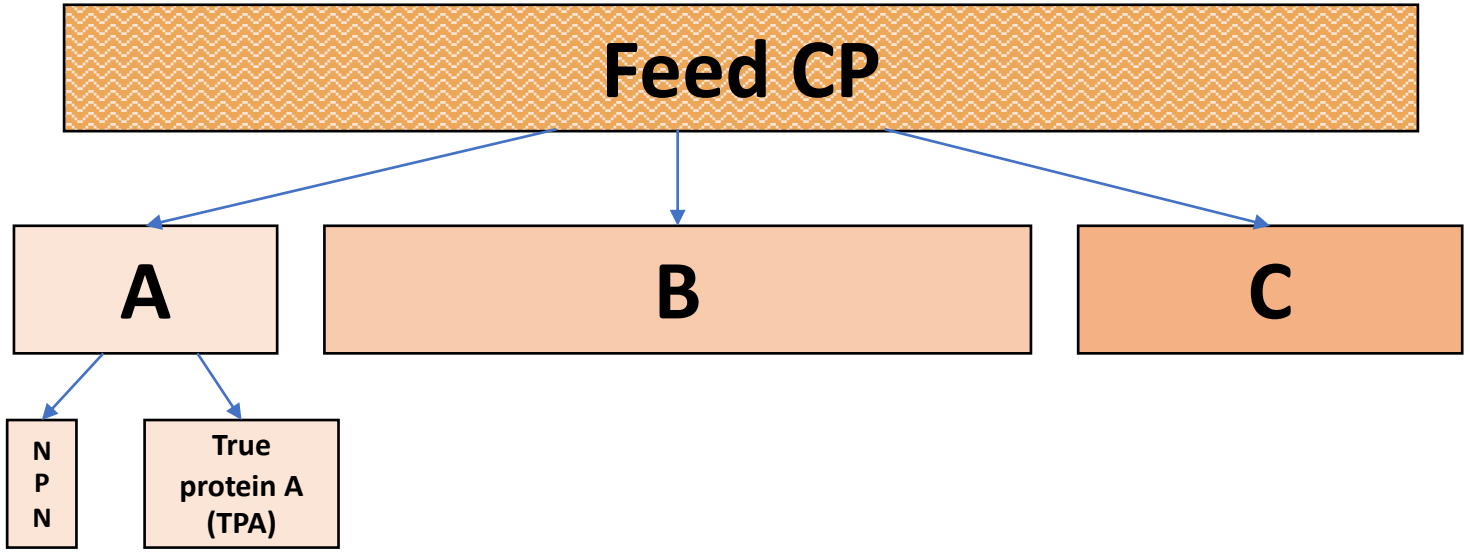
Absorbed (RDP)	RDP from A = NPN + 93.6*TPA	RDP from B $= \frac{Kd_i}{Kd_i+Kp_t} * B$	RDP from C = 0.0 * C	RDP total = (RDP from A) + (RDP from B)
Passes (RUP)	RUP from A = 6.4*TPA	RUP from B $= \frac{Kp_i}{Kd_i+Kp_t} * B$	RUP from C = 100.0 * C	RUP total = (RUP from A) + (RUP from B) + (RUP from C)
Notes	Absorbs or passes instantaneously. Fixed percentages of A absorbed vs. passing	Competitive absorption and passage of B fraction.	None absorbed, all C passes	It should always be true that: CP = (RDP total) + (RUP total) and that CP = A + B + C

Kp are specific to the feed type t

$$Kp_{forage} = 4.87$$

$$Kp_{concentrate} = 5.28$$

Kd are specific to each feed ingredient *i* (see Feed Tables, NASEM). For example, there is a Kd for “Corn Silage, Typical.”



Kp are specific to the feed type t

$$Kp_{forage} = 4.87$$

$$Kp_{concentrate} = 5.28$$

Kd are specific to each feed ingredient i (see Feed Tables, NASEM). For example, there is a Kd for "Corn Silage, Typical."

Absorbed (RDP)	RDP from A **= NPN** + 93.6***TPA**	RDP from B $= \frac{Kd_i}{Kd_i + Kp_t}$ ***** **B**	RDP from C = 0.0 ***** **C**	RDP total = (RDP from A) + (RDP from B)
Passes (RUP)	RUP from A = 6.4***TPA**	RUP from B $= \frac{Kp_i}{Kd_i + Kp_t}$ ***** **B**	RUP from C = 100.0 ***** **C**	RUP total = (RUP from A) + (RUP from B) + (RUP from C)
Notes	Absorbs or passes instantaneously. Fixed percentages of **A** absorbed vs. passing	Competitive absorption and passage of **B** fraction.	None absorbed, all **C** passes	It should always be true that: CP = (RDP total) + (RUP total) and CP = A + B + C

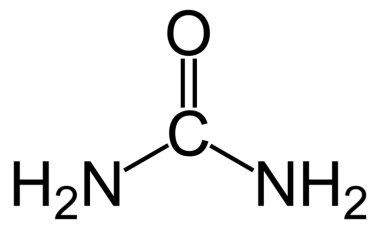
f$Fd_RUPIn <- (f$Fd_CPAIn-f$Fd_NPNCPIn) * fCPAdu

Kd are specific to FEEDS not category. Should have a different subscript.

- Ingestion
- Rumen degradation and passage
- Intestinal digestion and absorption
- Assimilation and/or use

The model describes the core sequences of nutritional processes (ingestion, digestion, absorption, assimilation/use) with respect to protein.

A.



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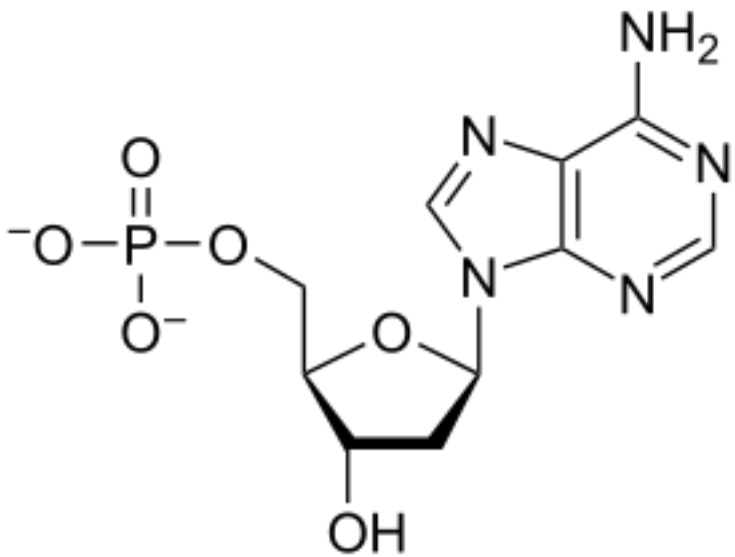

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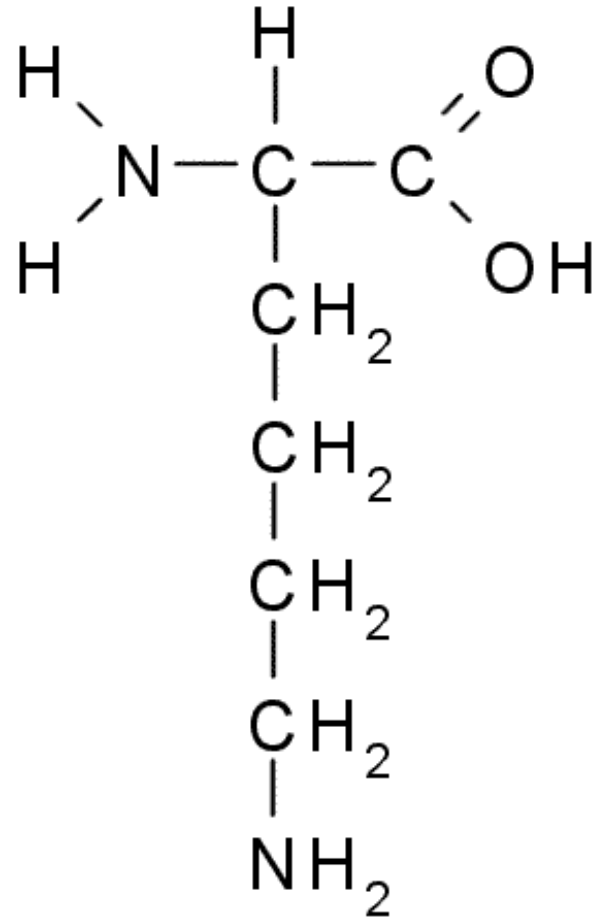
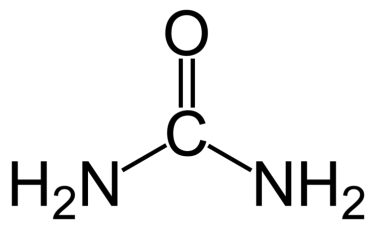


A.



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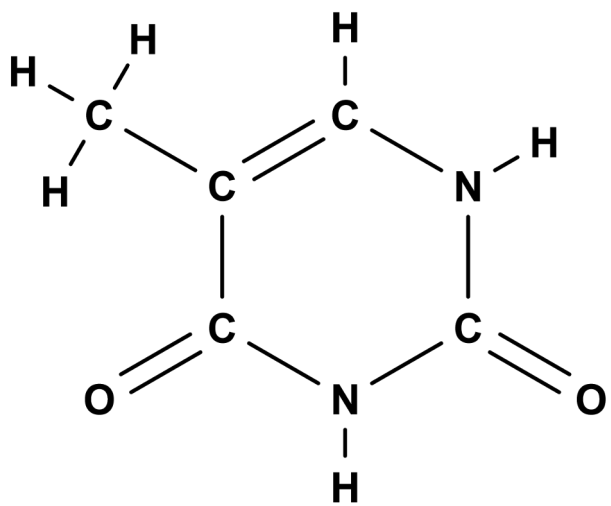
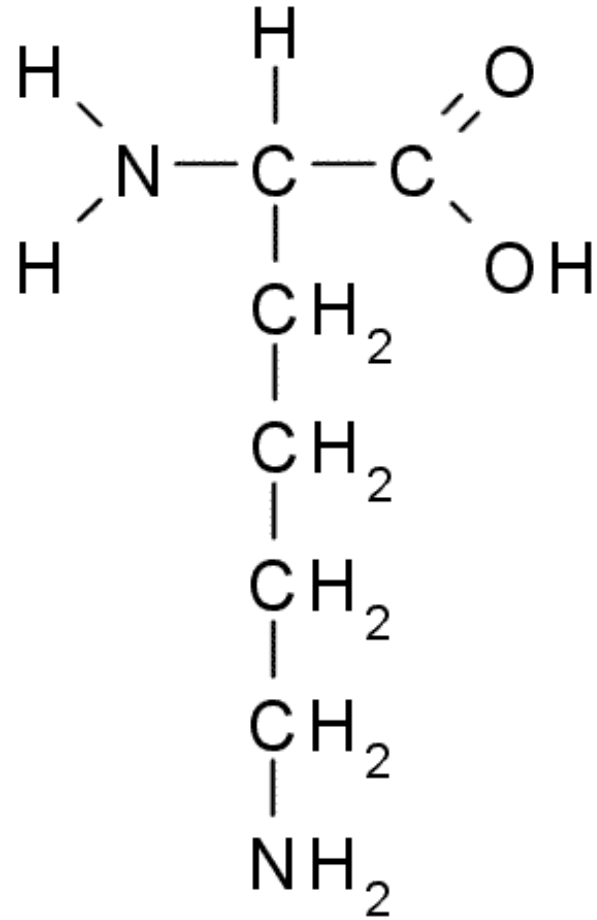
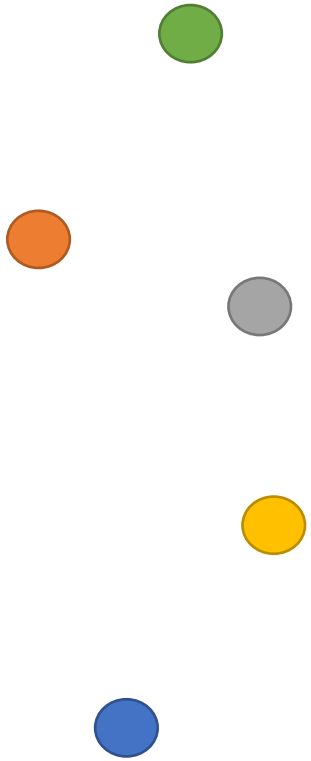


C.



A.



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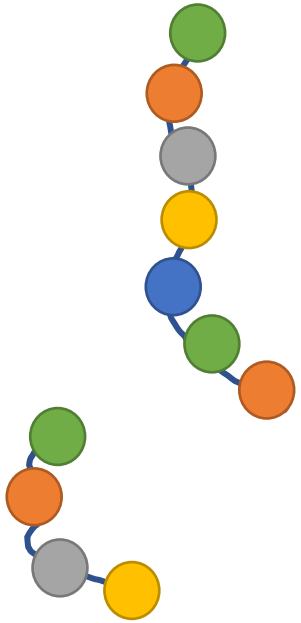

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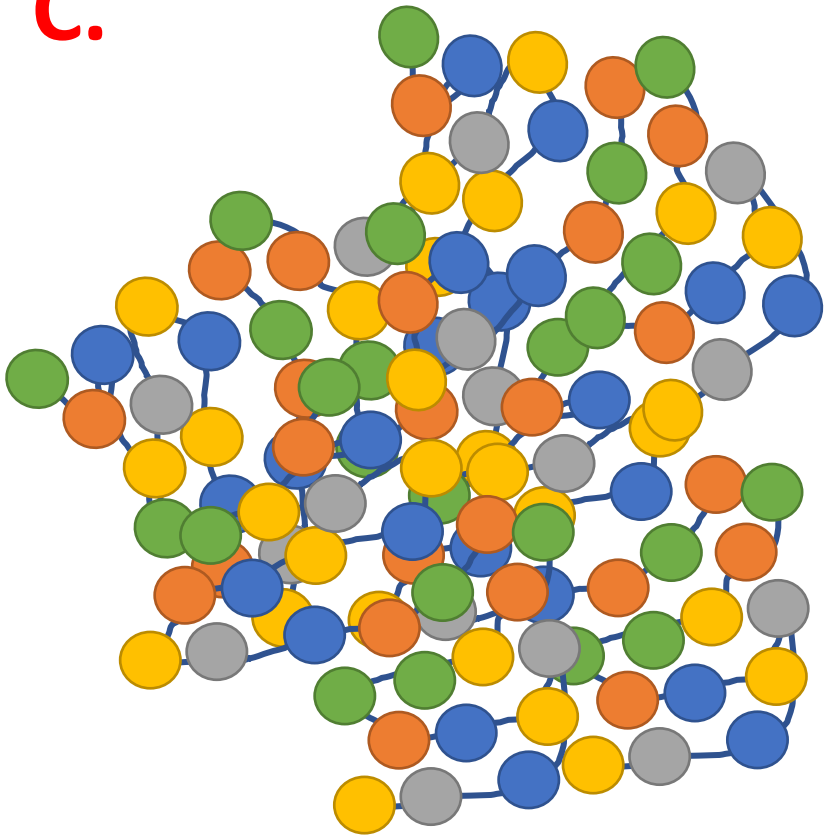
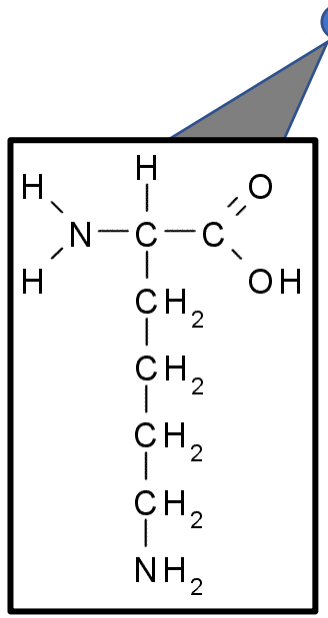
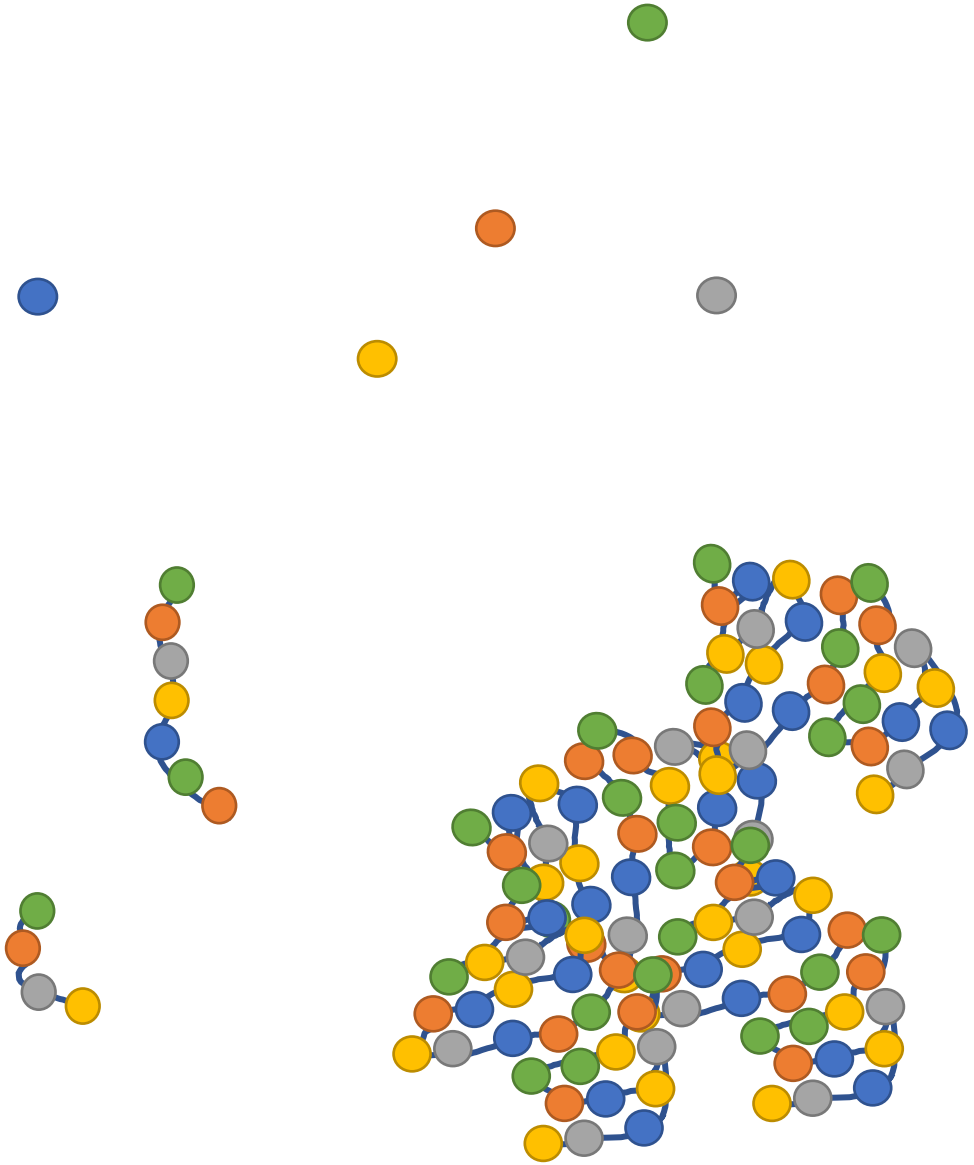
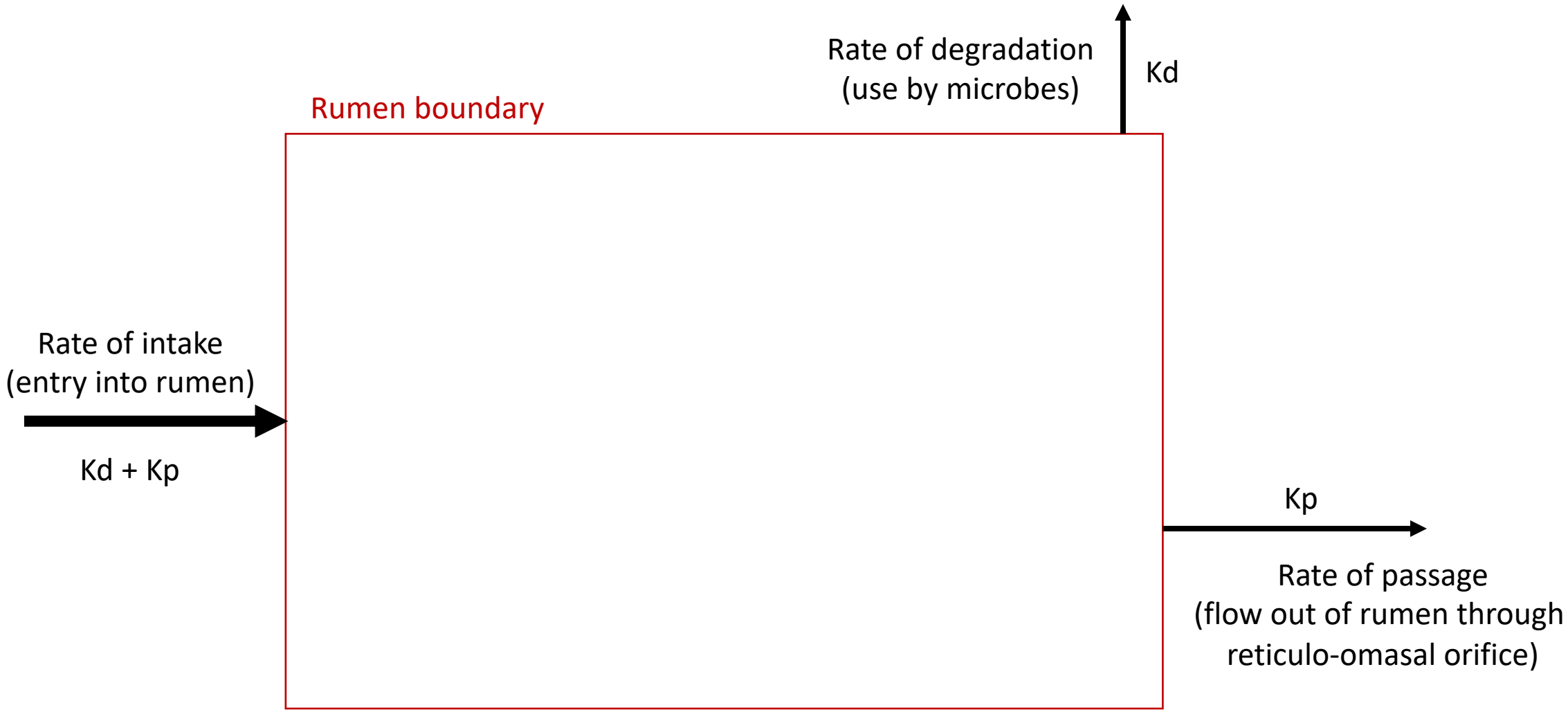
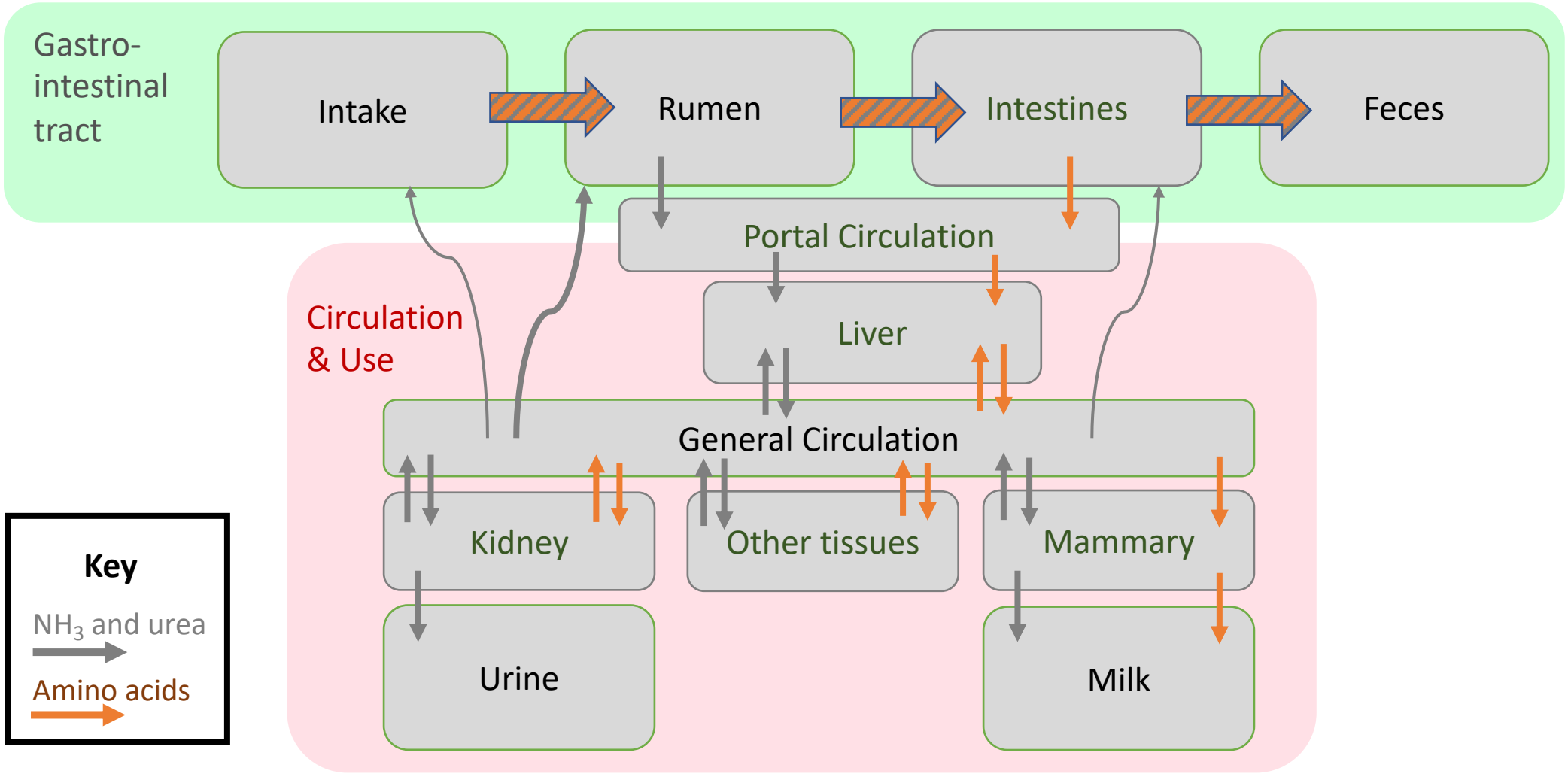
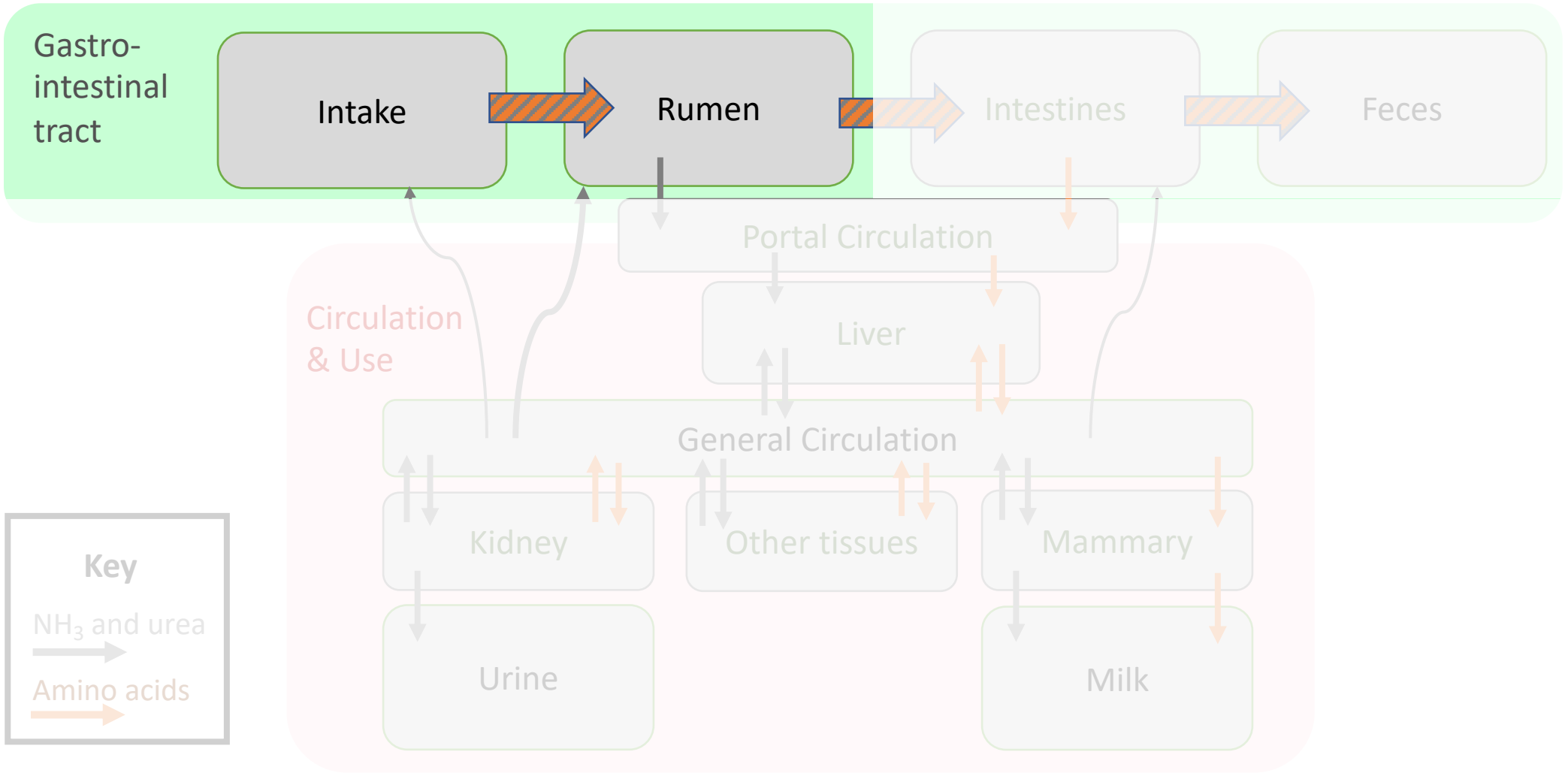


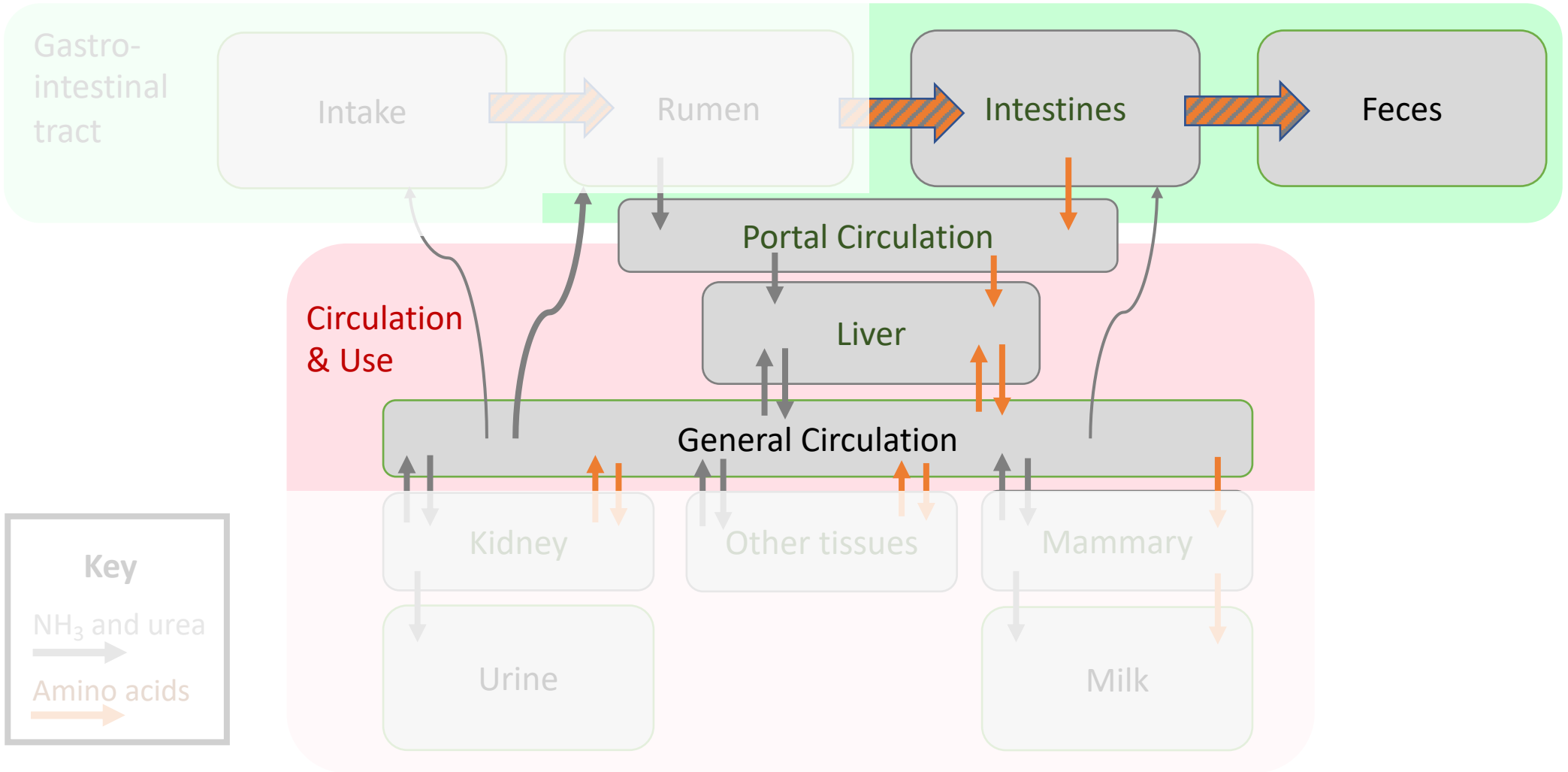

H
H
N
C
C
O
H
OH
CH2
CH2
CH2
CH2
NH2




Rate of degradation
(use by microbes)
Kd
Rumen boundary
Rate of intake
(entry into rumen)
Kd + Kp
Kp
Rate of passage
(flow out of rumen through
reticulo-omasal orifice)


Gastro-intestinal tract
Intake
Rumen
Intestines
Feces
Portal Circulation
Liver
Circulation & Use
General Circulation
Kidney
Other tissues
Mammary
Urine
Milk
Key
NH3 and urea
Amino acids


Gastro-intestinal tract
Intake
Rumen
Intestines
Feces
Portal Circulation
Circulation & Use
Liver
General Circulation
Kidney
Other tissues
Mammary
Urine
Milk
Key
NH_3 and urea
Amino acids


Gastro-intestinal tract
Intake
Rumen
Intestines
Feces
Portal Circulation
Liver
Circulation & Use
General Circulation
Kidney
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Mammary
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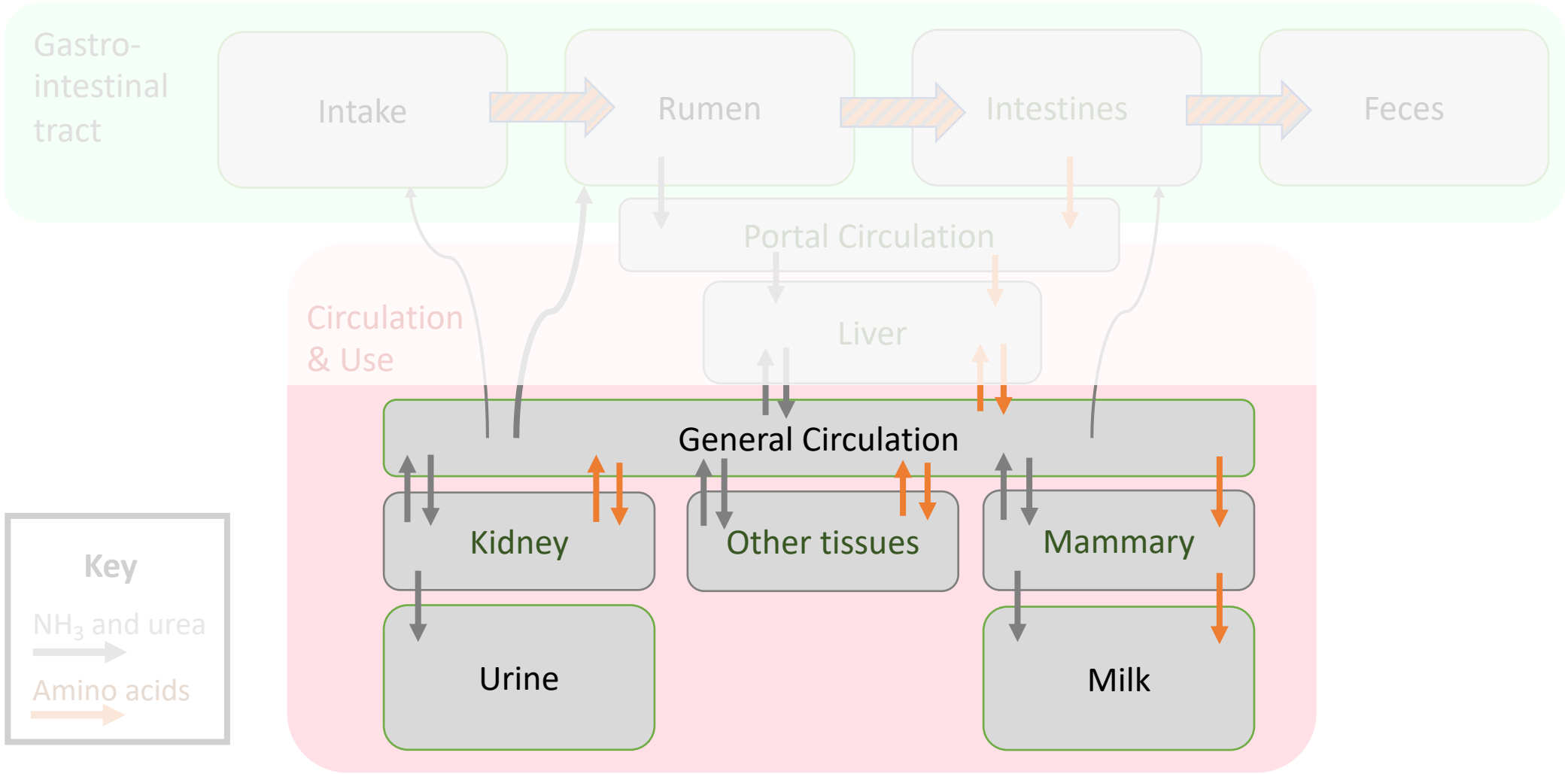
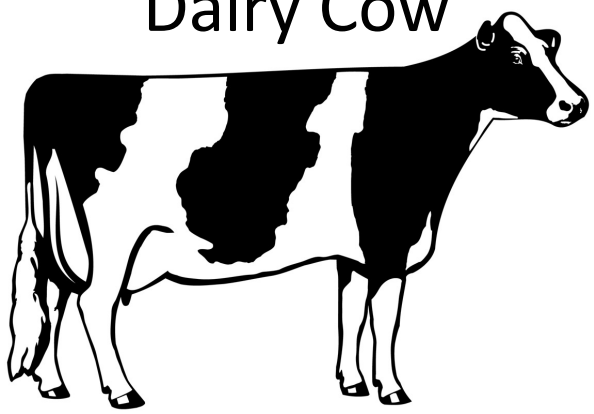
NH3 and urea
Amino acids


Gastro-intestinal tract
Intake
Rumen
Intestines
Feces
Portal Circulation
Liver
Circulation & Use
General Circulation
Kidney
Other tissues
Mammary
Urine
Milk
Key
NH_3 and urea
Amino acids

Sawdust

Dairy Cow



Ground Corn Grain

Fire

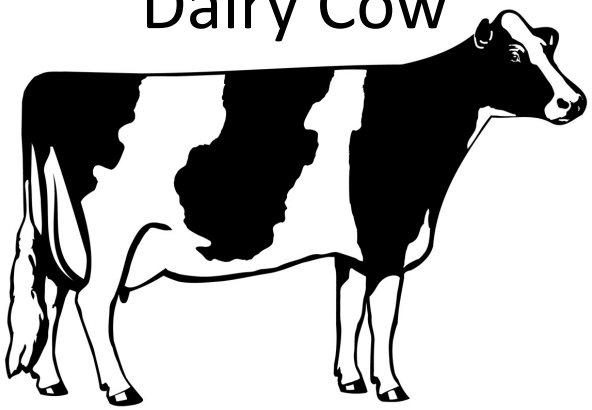
Sawdust

Ground Corn Grain

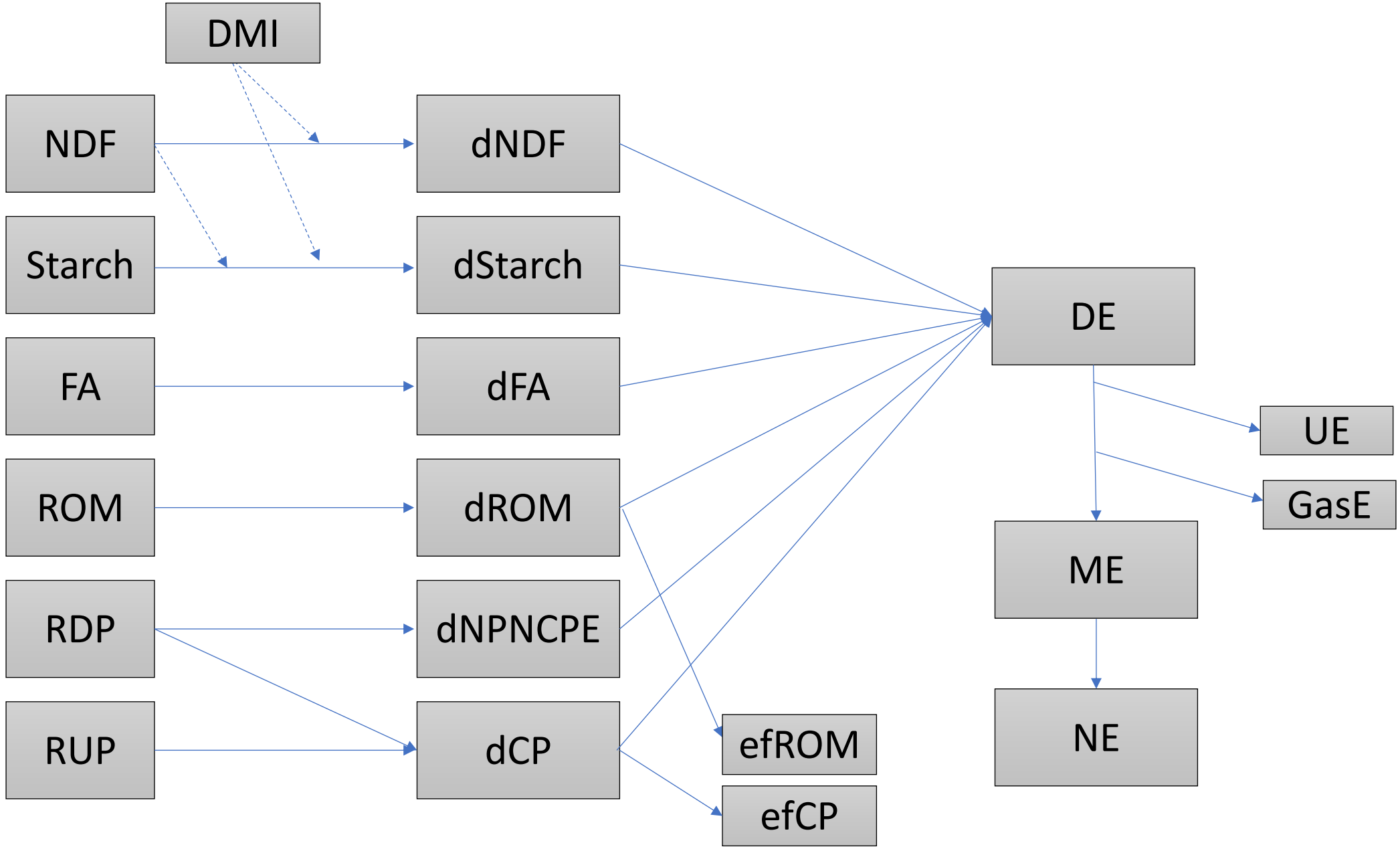
Fire

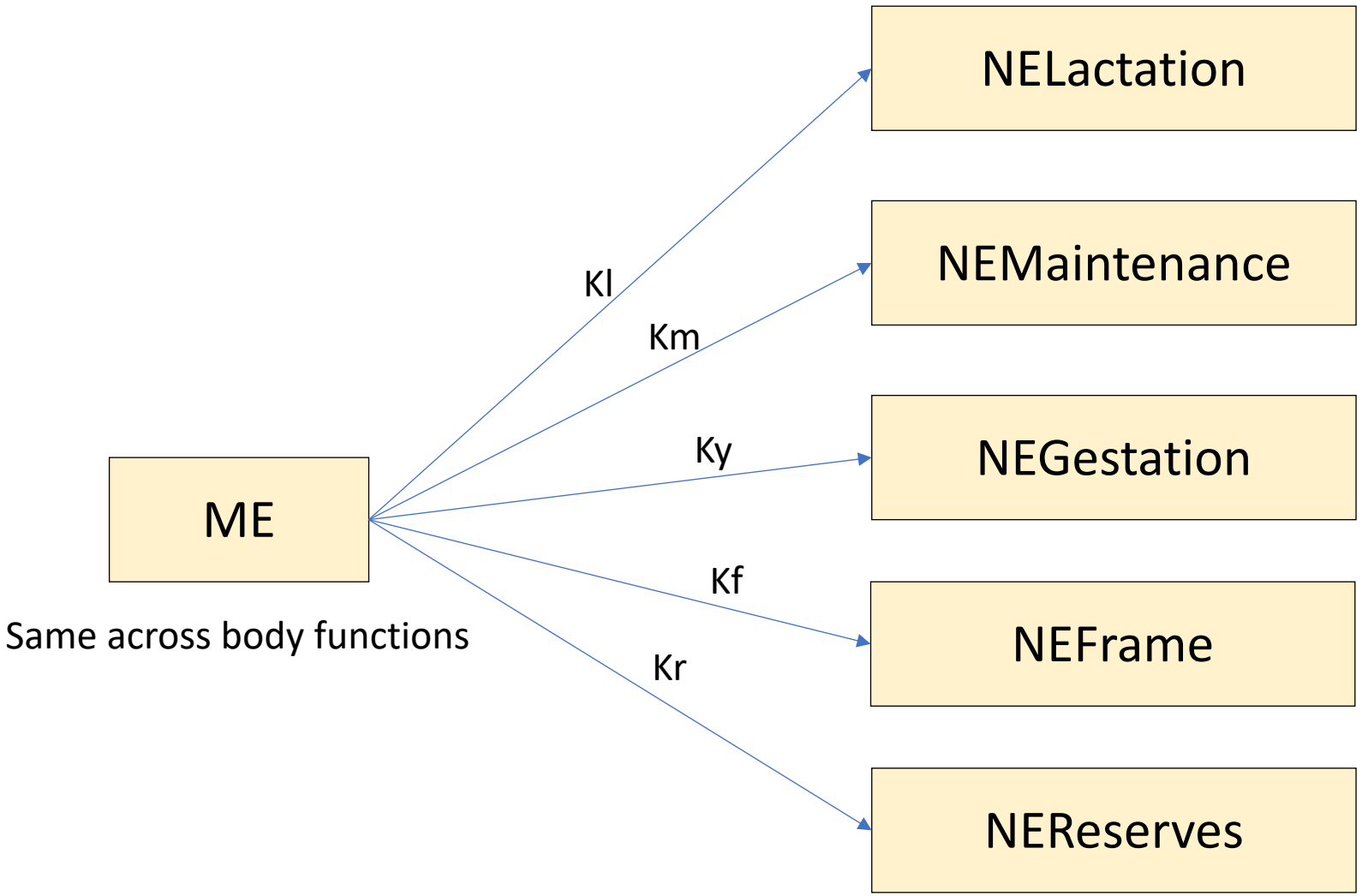
Sawdust

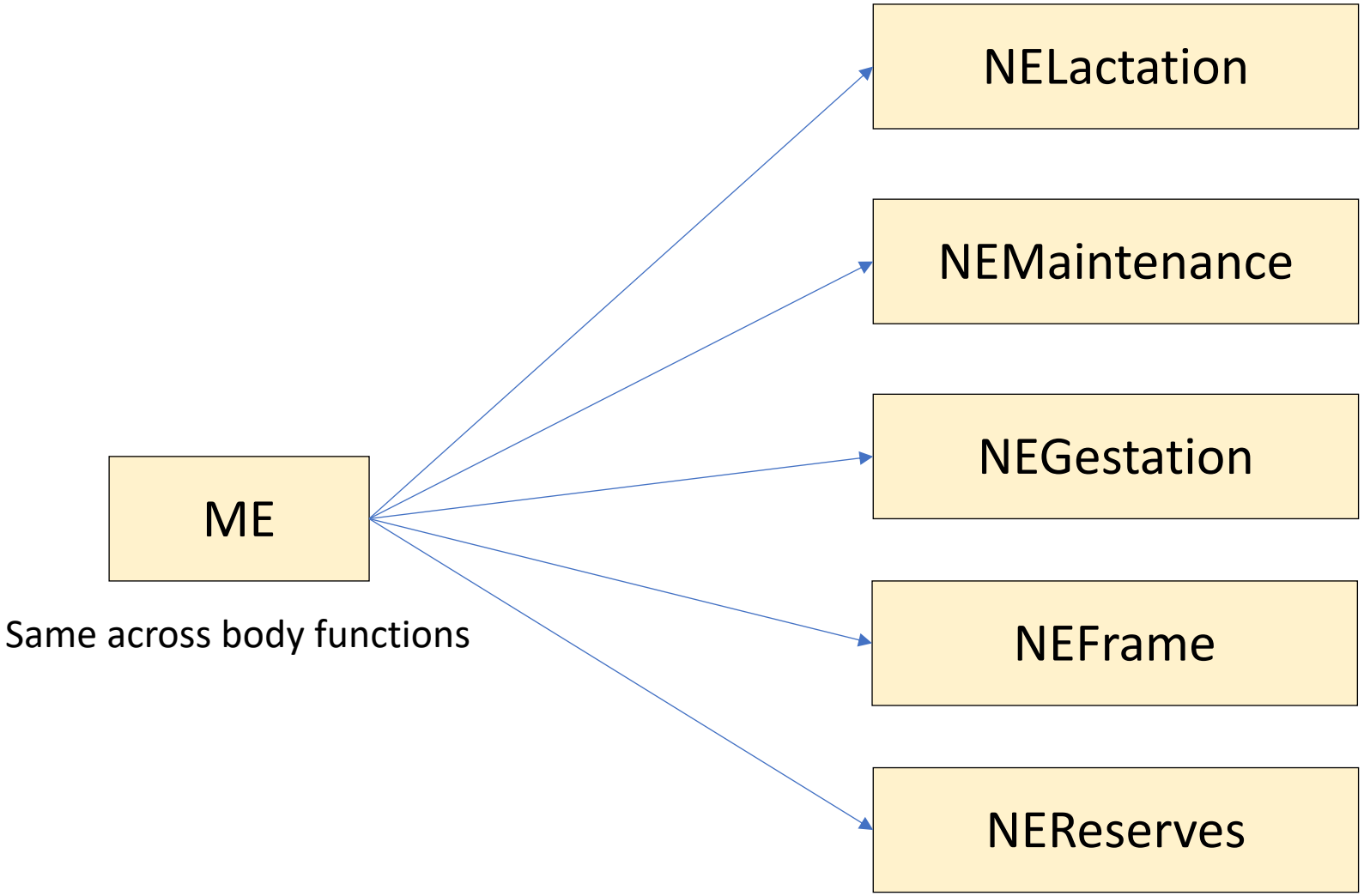
Dairy Cow



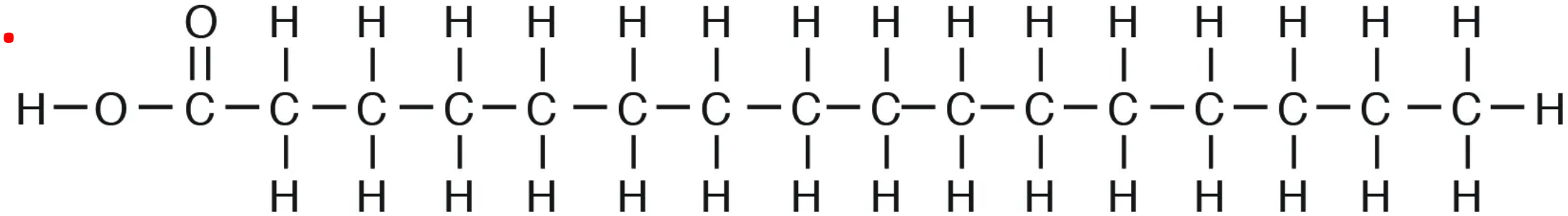
Ground Corn Grain


DMI
NDF
Starch
FA
ROM
RDP
RUP
dNDF
dStarch
dFA
dROM
dNPNCPE
dCP
efROM
efCP
DE
UE
GasE
ME
NE

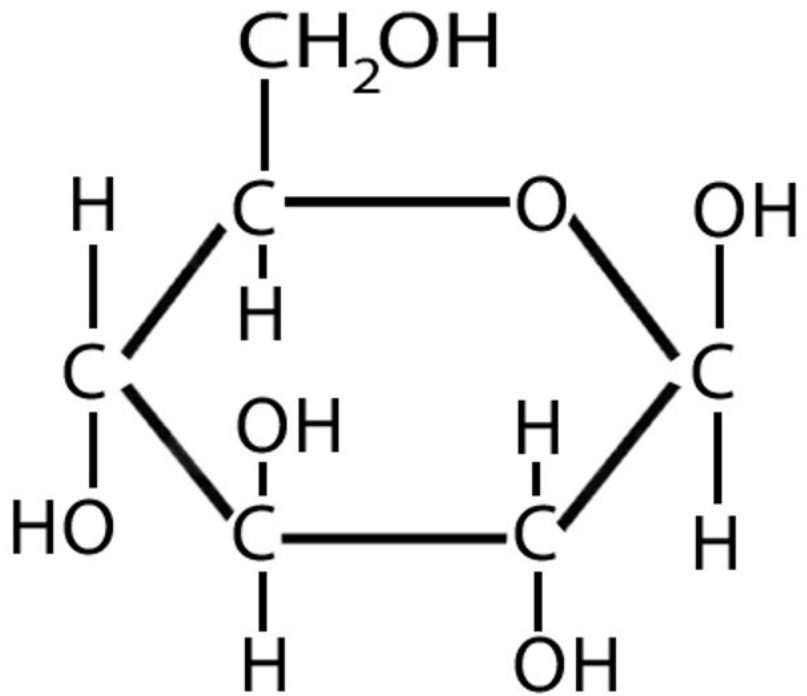

NELactation
NEMaintenance
Kl
Km
Ky
ME
Kf
NEGestation
NEFrame
Kr
NEReserves
Same across body functions


ME
Same across body functions
NELactation
NEMaintenance
NEGestation
NEFrame
NEReserves

A.



B.



C.