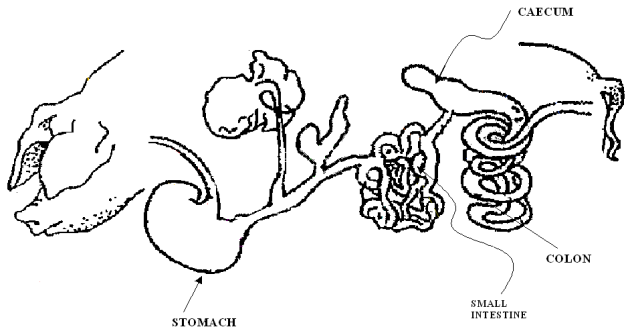
Functional Fibre for sows and growing pigs

Dave Cadogan



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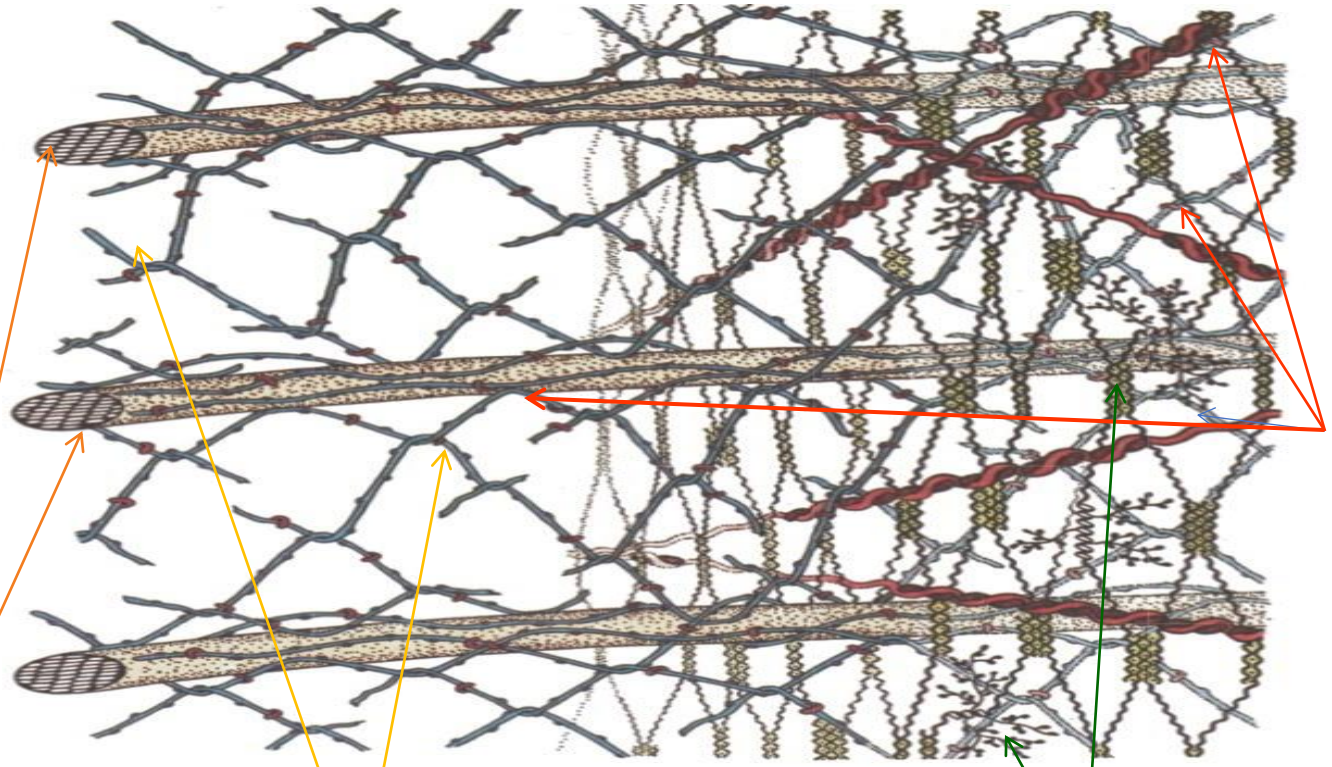
Structural Fibre/Carbohydrate in Grass



LIGNIN

CELLULOSE

XYLAN

PECTIN

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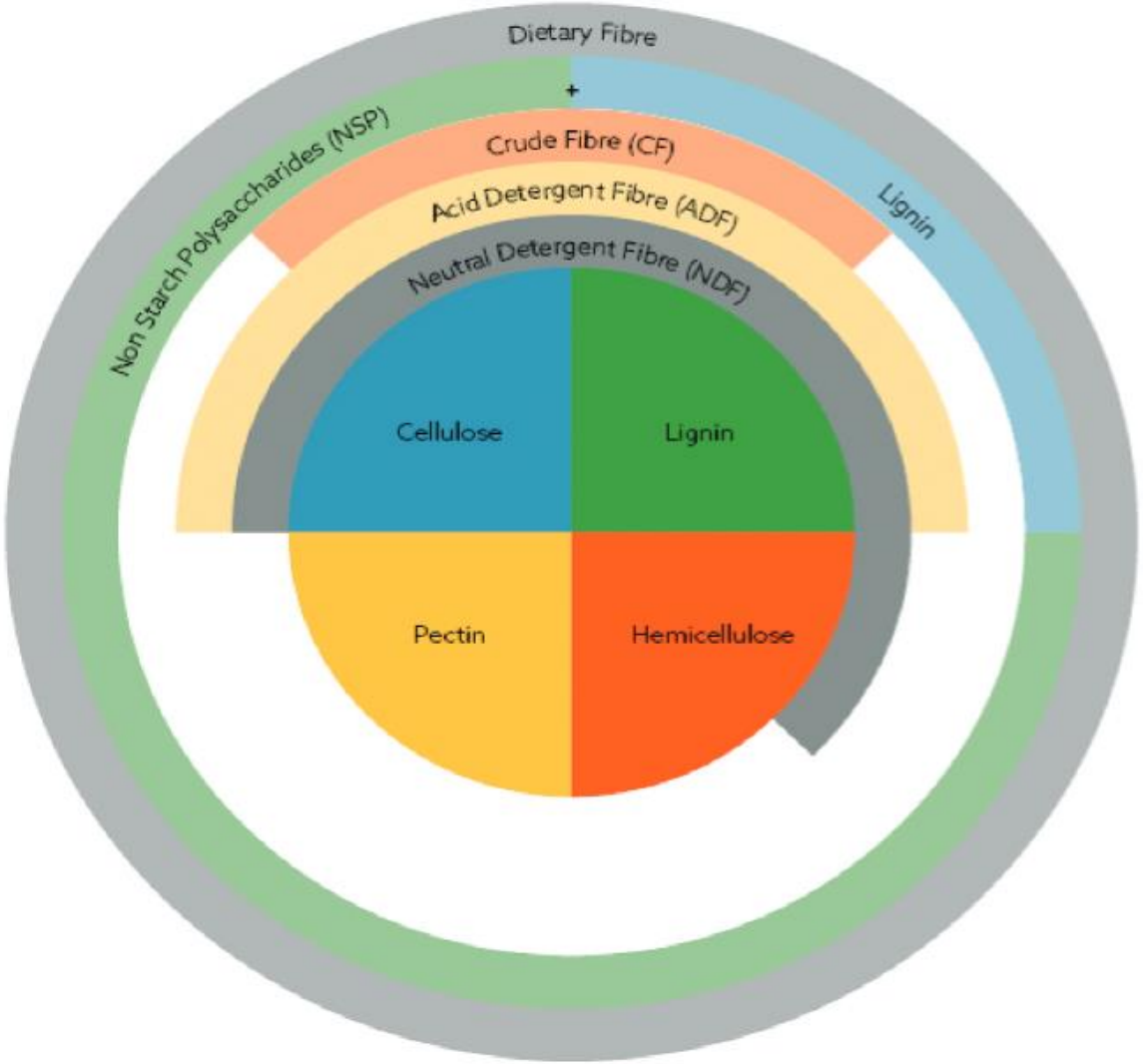
Composition of dietary Fibre



Adapted from Choct, 2015

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Crude Fibre is meaningless in diet formulation!

- Crude fibre = indigestible NSP + lignin
- The actual procedure only measures;
  - 50-60% of cellulose
  - 20% hemicellulose
  - Approx 70% of the lignin
- Only value is the measure of inert NSP and lignin

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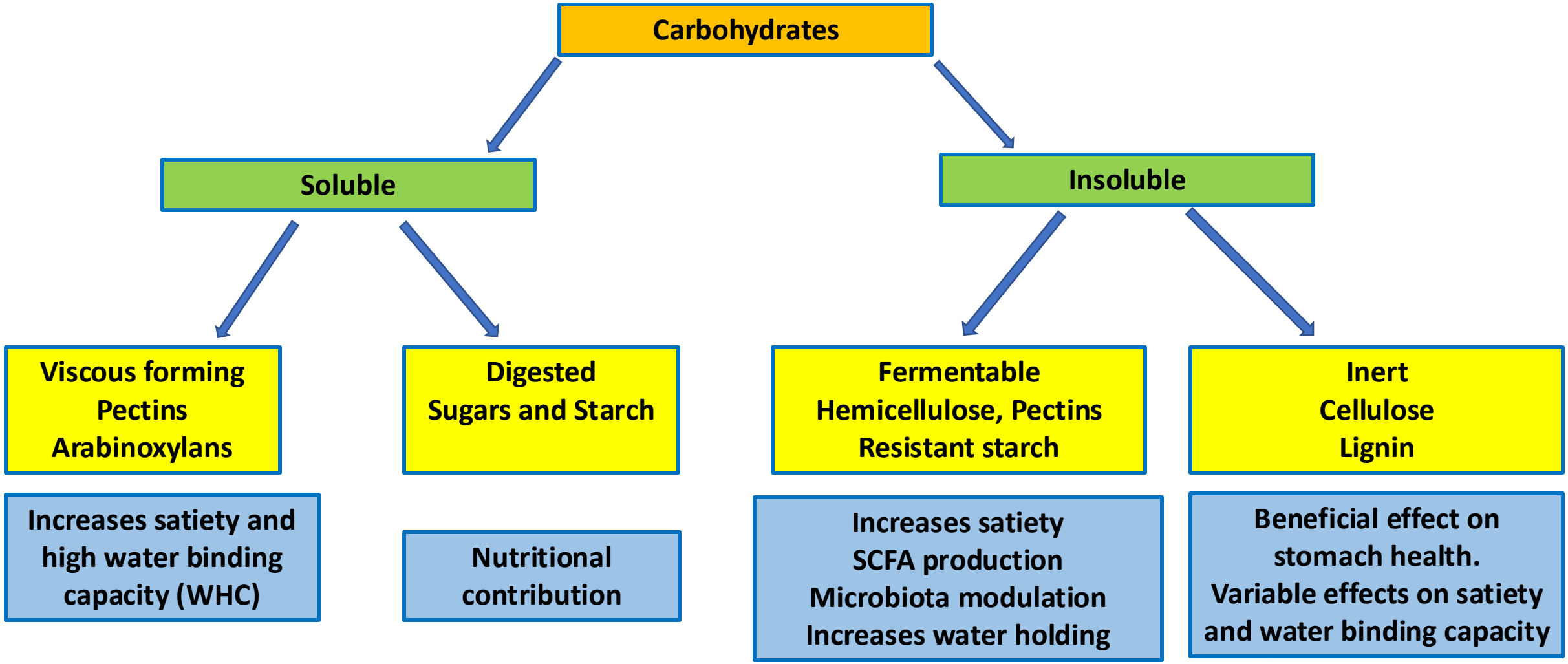
Another way of looking at the relationship of fibre fractions



Fibre Fractions of Raw Materials

Ingredient	NDF	ADF	Hemi-cellulose	Cellulose	Pectin	Lignin	Water soluble NSP	Water insoluble NSP	Total NSP
Soybean meal 48%	**7.5**	4.4	5.2	6.8	8.2	1.4	2.1	18.1	20.2
Soy hulls	**58.0**	42.0	33.0	10.5	21.5	1.5	3.2	61.8	65.0
Canola meal	**22.0**	18.0	14.3	5.0	9.9	7.0	7.8	21.4	29.2
Lupin	**22.0**	18.0	5.9	7.2	29.0	0.9	10.1	29.8	39.9
Lupin Hulls	**63.0**	51.0	6.0	42.0	30.0	1.5	10.9	67.1	78.0
Lupin Kernel	**12.5**	7.0	4.0	2.0	28.0	0.4	13.0	20.0	33.0
Pea	**13.0**	9.3	5.3	8.2	3.5	0.5	4.4	12.6	17.0
Chickpea	**11.9**	5.5	5.5	6.5	2.7	0.2	2.2	12.5	14.7
Faba bean	**13.8**	10.0	4.6	8.1	6.3	1.4	3.7	15.3	19.0
Mung bean	**12.1**	7.2	3.8	5.9	5.6	0.9	1.8	13.5	15.3
Lentils	**9.0**	7.0	1.8	3.9	1.5	1.8	1.2	6.0	7.2
Sunflower meal	**27.0**	19.1	11.1	22.8	4.9	8.2	0.3	38.5	38.8
Peanut meal	**14.5**	5.0	6.1	6.5	11.6	5.0	0.3	23.9	24.2
Sugar Beet Pulp	**39.0**	25.5	25.0	20.0	30.0	1.9	16.4	58.6	75.0
Palm Kernel meal	**65.8**	40.4	58.0	9.0	2.0	12.1	1.0	68.0	69.0
Sorghum	**8.0**	2.5	2.8	4.2	1.7	1.1	0.2	8.5	8.7
Maize	**9.0**	2.2	5.4	3.1	1.0	0.5	0.4	9.1	9.5
Wheat	**12.0**	3.5	6.7	3.2	0.4	1.0	1.6	9.7	11.3
Triticale	**14.0**	3.8	7.0	3.3	0.5	1.2	1.2	10.3	11.5
Millrun	**40.0**	12.7	23.4	9.7	1.2	2.6	3.7	30.7	34.4
Wheat Bran	**44.0**	13.0	34.4	17.5	1.8	6.5	2.0	51.9	53.9
Wheat Pollard	**32.0**	11.0	18.8	8.2	1.5	3.1	2.6	25.9	28.5
Barley	**21.0**	5.5	11.2	4.5	1.4	1.0	2.2	14.9	17.1
Oats	**33.0**	16.0	11.1	21.5	1.7	2.5	1.6	32.7	34.3
Oat hulls	**77.5**	40.5	37.0	39.9	1.5	5.6	0.9	72.5	73.4
Wheat Straw	**72.1**	45.8	29.0	48.0	5.0	15.0	0.5	82.0	82.5

Sources: Premium Nutrition Atlas 2019; Moss et al, 2018

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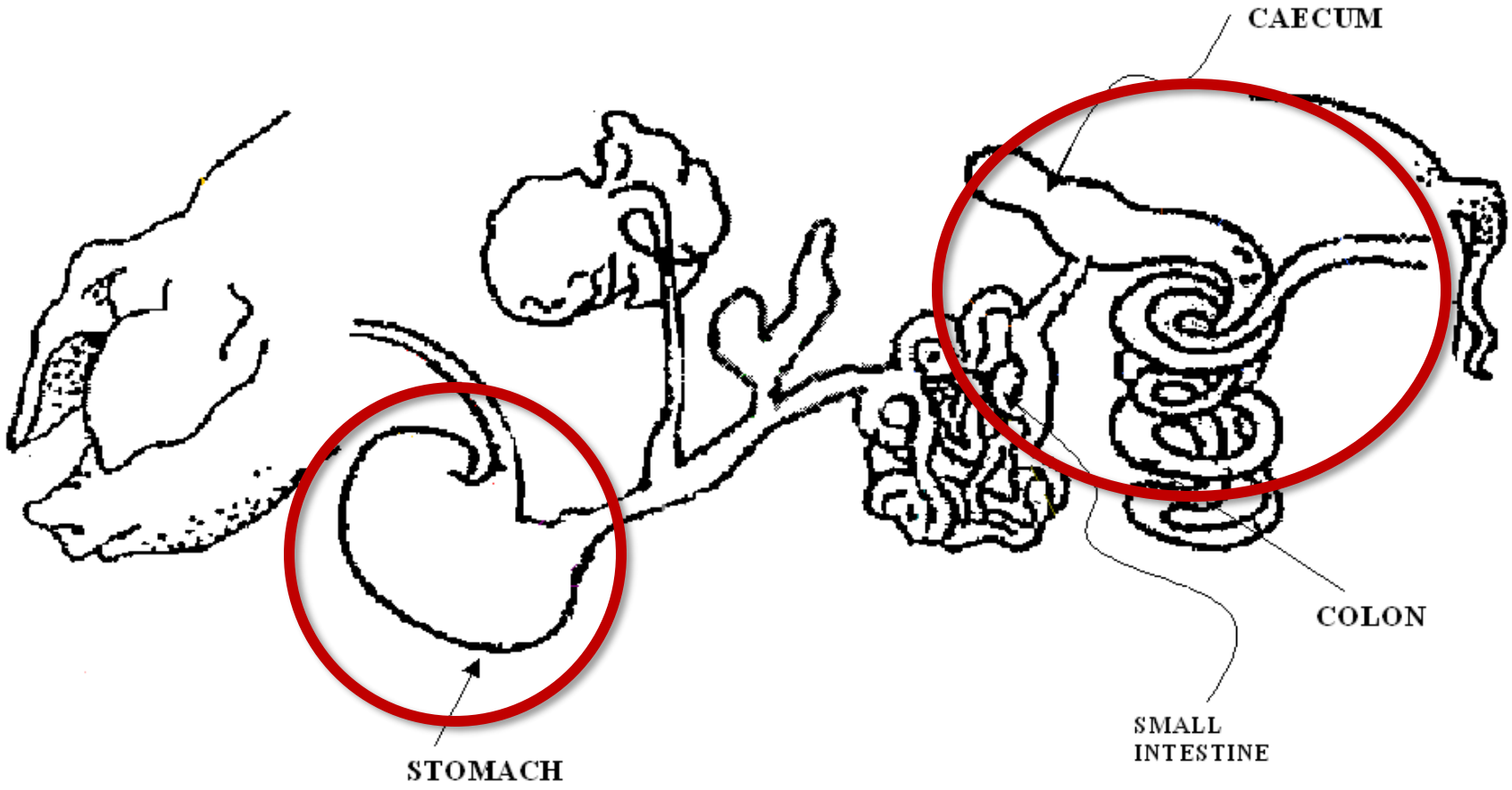
How functional fibre improves Satiety



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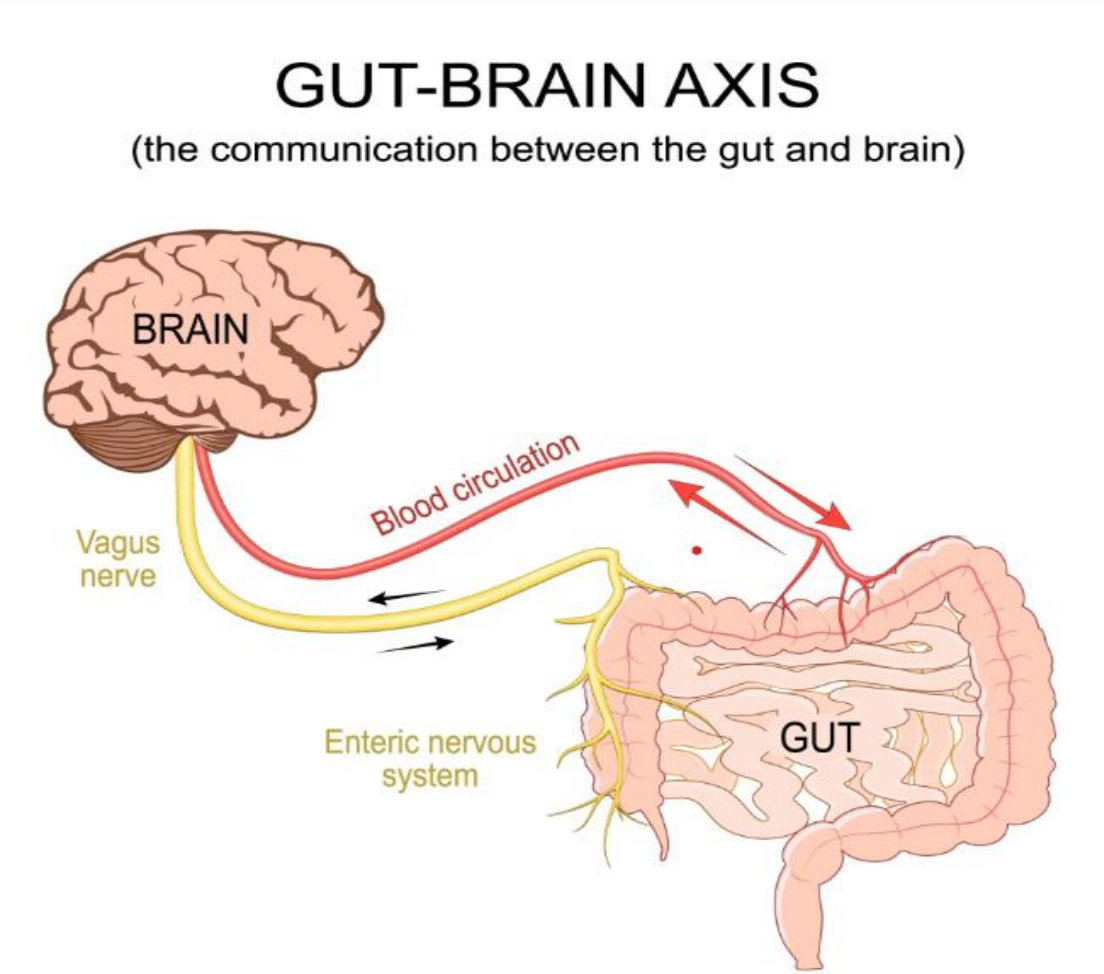
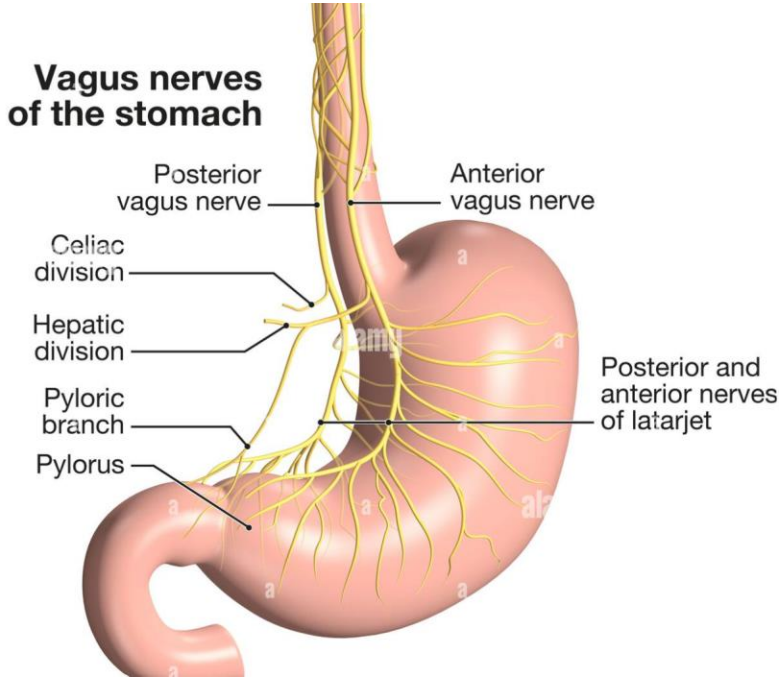
The Brain Gut Axis: Vagus nerve and gut hormones





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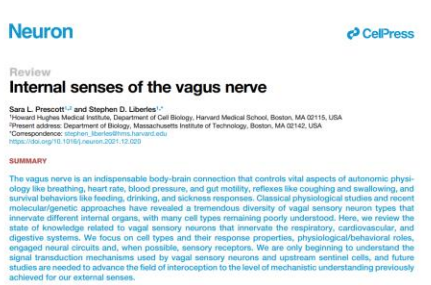
Gut brain axis: The vagus nerve


Neuron

CellPress

Review

Internal senses of the vagus nerve

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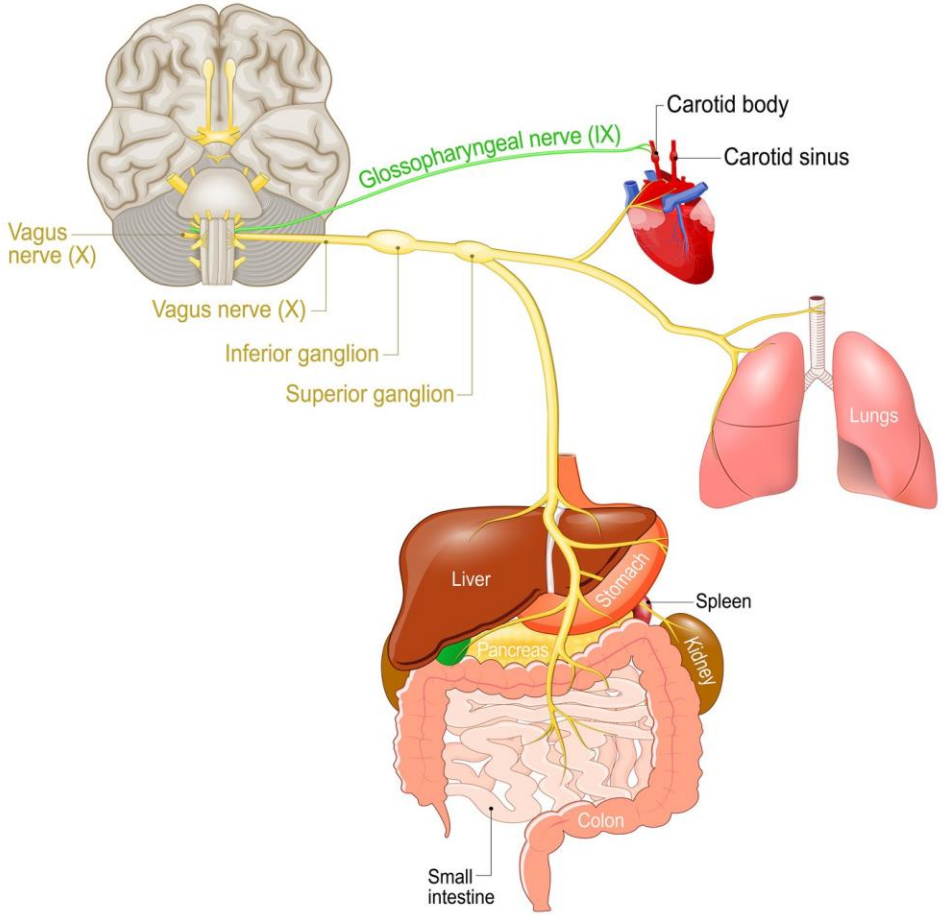
SUMMARY

The vagus nerve is an indispensable body-brain connection that controls vital aspects of autonomic physiology like breathing, heart rate, blood pressure, and gut motility, reflexes like coughing and swallowing, and survival behaviors like feeding, drinking, and sickness responses. Classical physiological studies and recent molecular/genetic approaches have revealed a tremendous diversity of vagal sensory neuron types that innervate different internal organs, with many cell types remaining poorly understood. Here, we review the state of knowledge related to vagal sensory neurons that innervate the respiratory, cardiovascular, and digestive systems. We focus on cell types and their response properties, physiological/behavioral roles, engaged neural circuits and, when possible, sensory receptors. We are only beginning to understand the signal transduction mechanisms used by vagal sensory neurons and upstream sentinel cells, and future studies are needed to advance the field of interoception to the level of mechanistic understanding previously achieved for our external senses.

Prescott and Liberies, 2021

- Regulates feed intake through receptors in the stomach, small intestine and colon
- Has both mechanosensory neurons and chemosensory neurons
- Stimulated by both gut hormones (CCK, GLP1 and **PYY**) and gut distension/fill



Gut hormones
GLP1 = Glucagon like peptide 1
CCK = cholecystokinin
PYY = Peptide Tryosine Tryosine

Glucagon like Peptide 1 (GLP 1) and satiety

Elimination of all dietary fibre in mice reduced GLP 1 by 37% in the ileum and 55% on the colon.

(Hunt et al, 2021)

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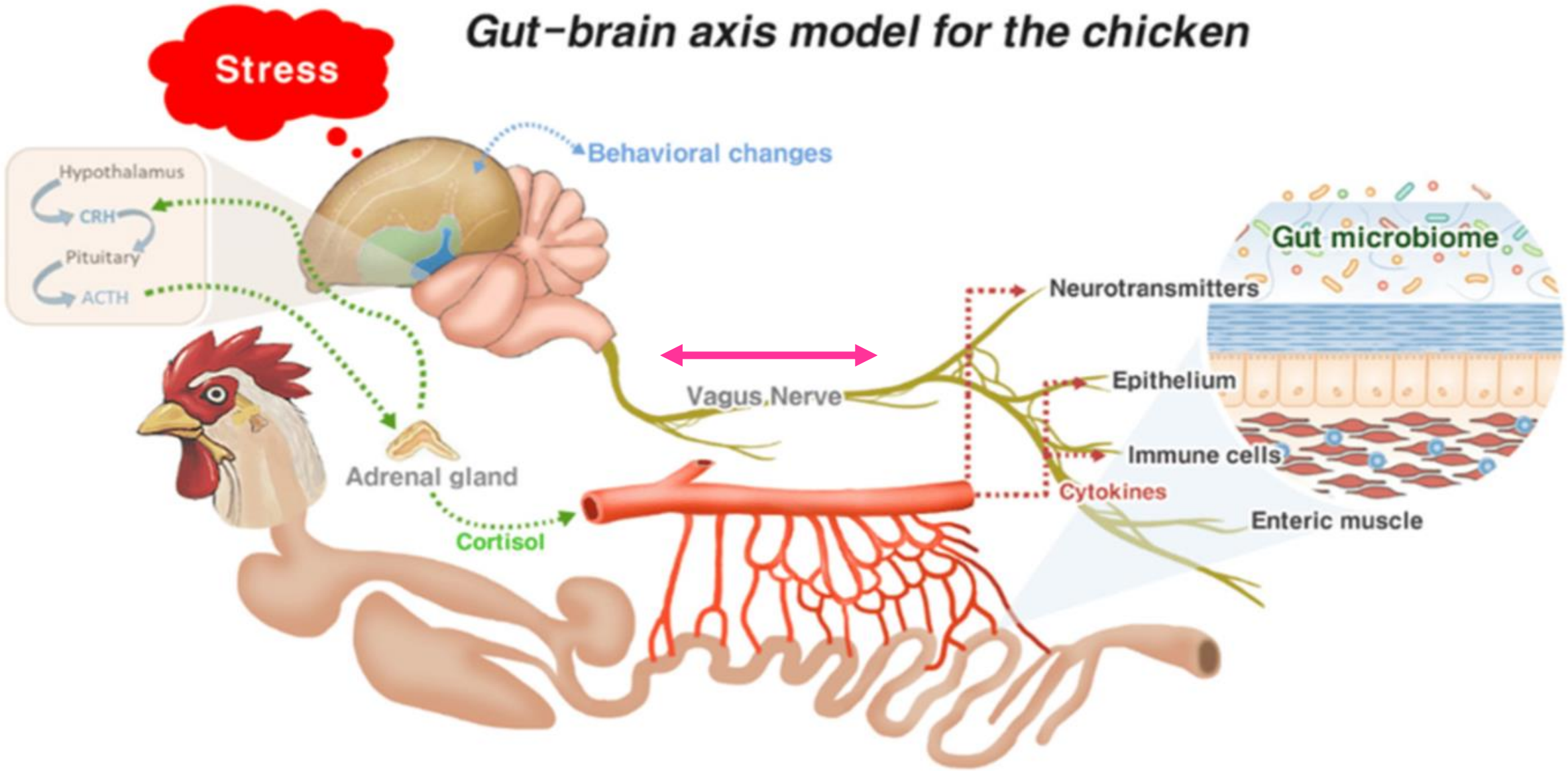
Hunger and stress?



Mode of action: Functional fibre induces satiety

i. Soluble viscous producing fibre slowing down digesta rate in upper GI tract

ii. Coarse physical structural fibre (eg coarse wheat bran/Barley) maximising gut fill and function

iii. Swelling and retention by ingredients high in fibre and water holding capacity

iv. Highly fermentable fibre (eg soluble pectin) producing gas end products distending stomach, distal gut and colon

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Dietary fibre and Water Holding Capacity of Raw Materials

	Water Holding Capacity kg/kg	Dietary fibre (%)	NDF	lignin	Soluble Dietary fibre	Pectin
Wheat	**1.5**	12.7	10	1.0	1.6	0.4
Sorghum	**1.6**	8.0	8	1.1	0.2	1.7
Barley	**2.3**	18.1	21	2.5	2.2	1.4
Soybean 48% CP	**3.6**	21.6	8.4	1.4	2.1	8.2
Canola meal 36% CP	**3.4**	36.2	27	7.0	7.8	9.9
Millrun (pollard and bran)	**4.0**	39.2	34	6.0	3.7	1.2
Soybean Hulls	**5.0**	66.5	58	1.5	3.2	21.5
Wheat Bran	**4.5**	60.1	45	6.5	2.0	1.5
Sugar cane bagasse	**7-8**	89.5	62	11.2	0.8	0
Modified Ligno-Cellulose (Arbocel, Opticell)	**7-10**	89.0	70	8.0	0.4	1.0
Sugar Beet Pulp	**7-15**	76.9	37	1.9	16.4	30.0
Pure Pectin	**56.2**	85.7	0	0	40.0	98.0

Premier nutrition Atlas, 2019; Stephan and Cummings 1979

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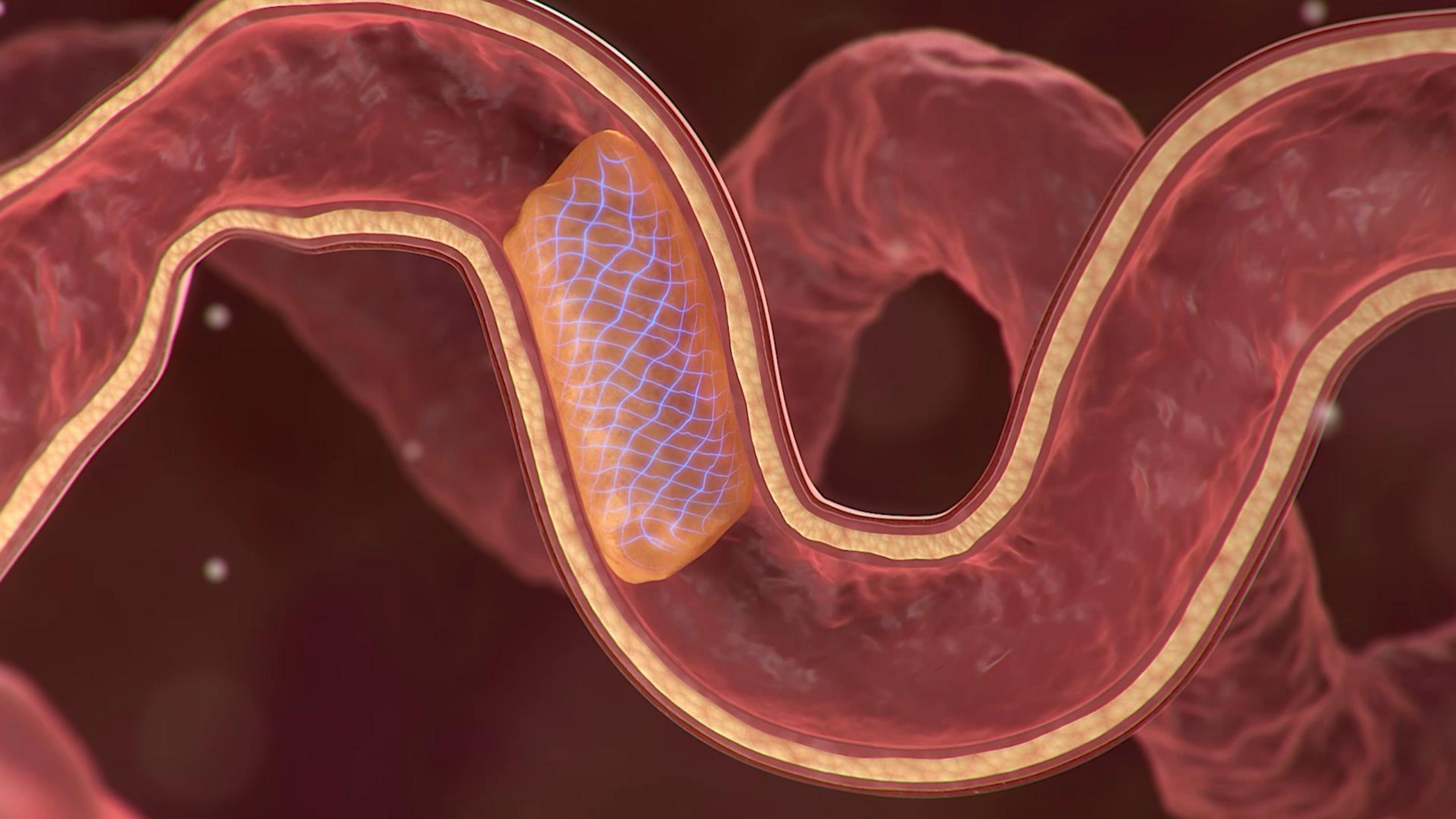

Best options for functional fibre for Satiety

Millmix or Wheat bran/pollard

Lupin or Soy Hulls

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Water holding capacity (modified lignified cellulose)

200 grams of water

25 grams of lignified cellulose (Arbocel)

800% water holding capacity

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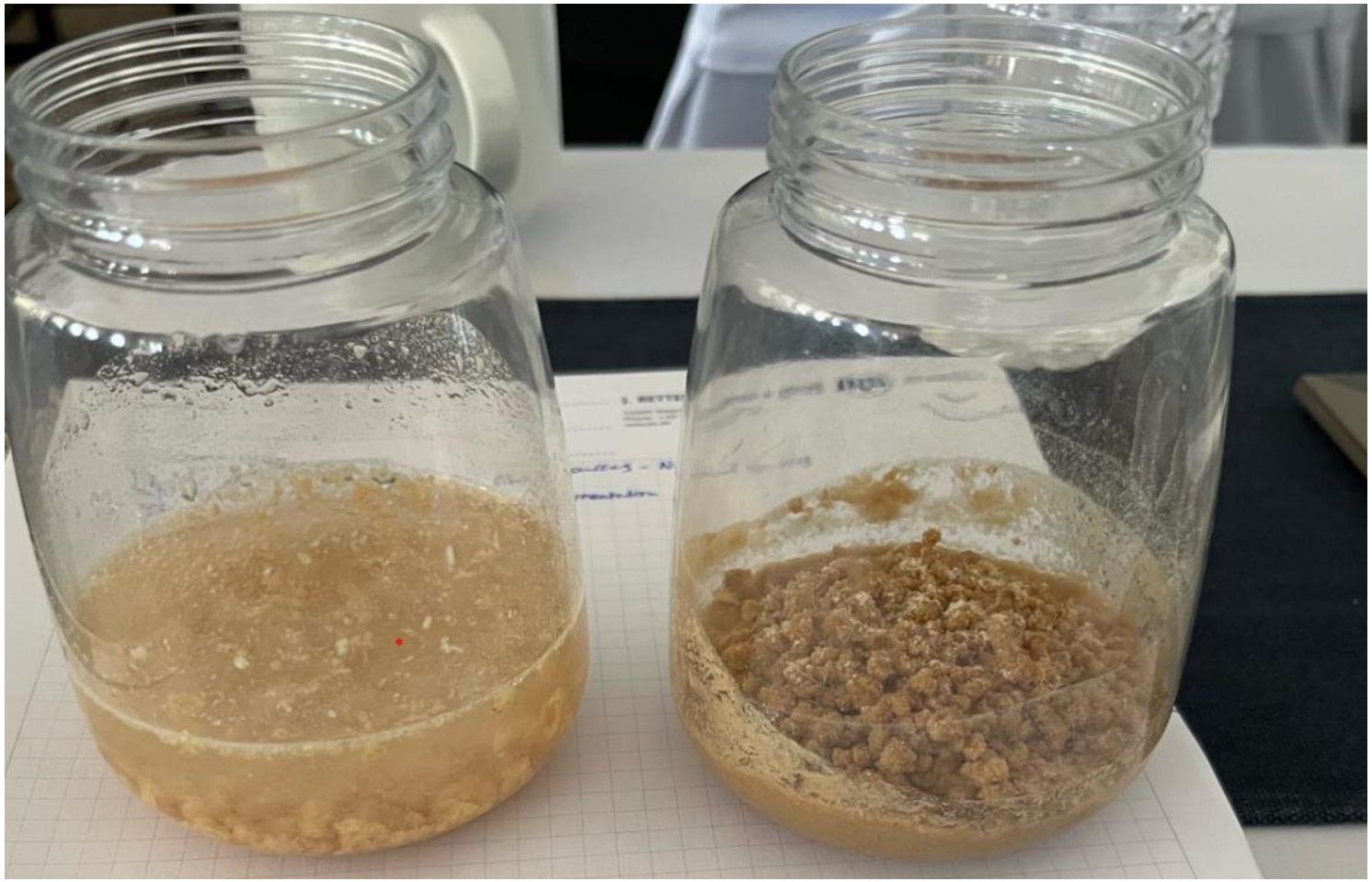
Water swelling differences between specialised fibres



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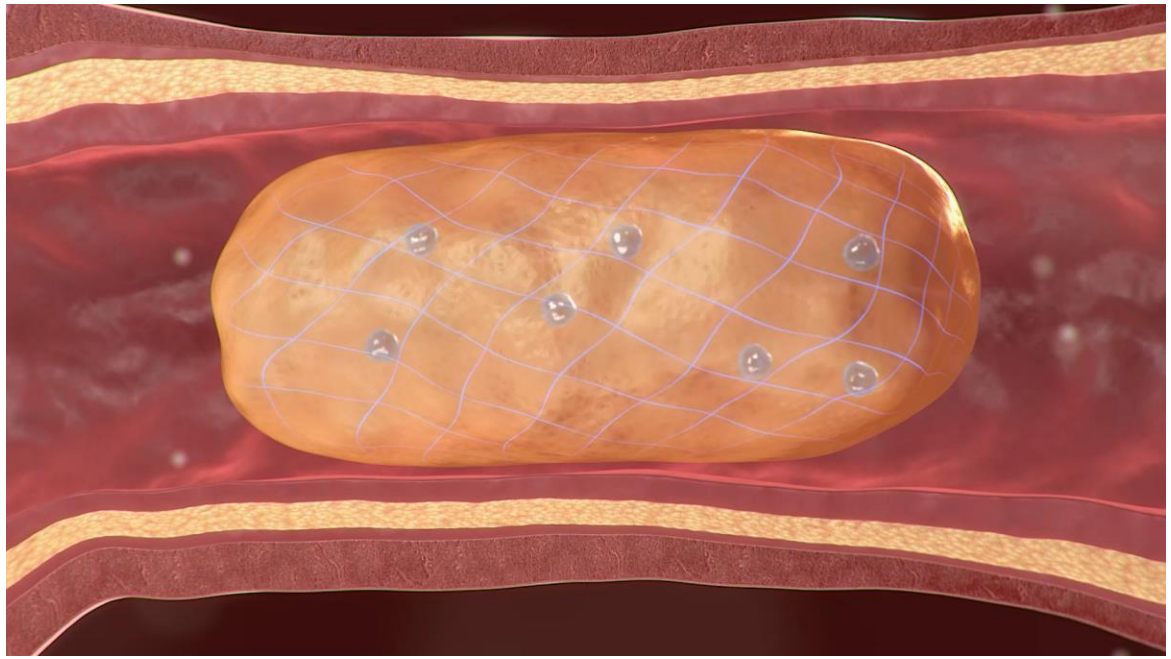
Gradual release of free water in distal gut

- Functional fibre with high water binding capacity slow release of water in colon
- This limits excessive water release in particular areas of the distal gut
- Reduces constipation



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Faecal bulking properties of different NSP

Item	Water holding Capacity (g/g)	Change in faecal bulk after 24 hours
Wheat Bran	4.2	117%
Bagasse	5.7	124%
Apple	12.8	40%
Pectin	56.2	19%

Study using 8 human volunteers; data corrected to 20g of dietary fibre intake per day

Faeces collected and water added and bulking/water holding effect of matter measured after 24 hours

(Stephen and Cummings, 1979)

Particle size and functional fibre

Fibre/NSP and WHC “requirements for pig breeders”

Diet type*	Minimum NDF**	Ideal NDF	Maximum NDF	Water Holding Capacity
Gestation	**18%**	**21%**	**25%**	**2.5 to 3%**
Pre-Lactation	19%	22%	25%	**3%**
Lactation	16%	18%	23%	**2.0 to 3%**

** For pelleted diets. Can lower min by 2% for rolled mash diets*

***The NDF does not really measure the pectin*

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Ideal fibre limits for pigs

Diet type	Minimum hemi-cellulose*	Max hemi-cellulose	Minimum Pectin	Maximum Lignin
Weaner	5%	7%	0%	0.5
Grower	6%	8%	0%	1.5
Finisher	8%	10%	0%	2
Gestation	11%	13%	3.5%	2%
Pre-Lactation	12%	15%	3%	2.5%
Lactation	10%	12%	2%	1.8%

Depends on particle size and swelling ability; coarse particles reduce min requirement

Concluding remarks feed intake modulation by fibre

- Functional fibre can significantly influence feed intake
- **Insoluble dietary fibre** with high affinity for **water binding and swelling is superior than soluble fibre**
- Functional fibre directly effects the gut hormones and vagus nerve
- Further work required to assess best water binding properties and fine tuning of minimum levels of functional dietary fibre

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