Bioactive Peptides – a new tool in the feed technology toolbox

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South African Feedlot Association Conference *29 July 2026*

Man’s quest for tools …

+

Man’s “exponential” increase
in technological capabilities …


SPEED 78 KM/H
ALTITUDE 0 KM
LOX
CH4
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STARSHIP FLIGHT TEST
SPEED 16573 KM/H
ALTITUDE 144 KM
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LIVE 1.8M views

Why the quest for new tools ?

The perpetual need for improvement …

- Production
  - Growth rate
  - Feed efficiency
  - Slaughter %
  - Carcass weight
- Product quality
- Animal wellbeing
- Environmental sustainability
- Return on investment

The perpetual need for improvement …

- Production
  - Growth rate … **ADG = 1.65 kg; carcass ADG = 1.22 kg**
  - Feed efficiency … **5.5 (DM basis); 7.5 carcass FCR**
  - Slaughter % … **58.8**
  - Carcass weight … **285 kg (CCW)**
- Product quality
- Animal wellbeing
- Environmental sustainability
- Return on investment

Two notable champions from the past

- First: Ionophores
  - Monensin (Rumensin™)
  - Late 1970s

- Second: Beta-agonists
  - Zilpaterol hydrochloride (Zilmax™)
  - Mid 1990s

- Next: Bioactive peptides ???

The ~~*Bermuda*~~ feedlot triangle

- Weaner calf price
- Feed cost … nutrition → → →
- Carcass price

→ → → Profit

Importance of nutrition

- Purpose:
  - Supply nutrients – energy, protein (amino acids), minerals, vitamins
- Affects:
  - Rate of production ($ADG_{carcass}$) and efficiency of production ($FE_{carcass}$)
- Primary cost item
- Often the only thing that the feedlot operator can control/ manipulate…

Feed additives

- Feed additives are non-nutritive substances added to feed to improve the conversion of feed → meat & milk
- Examples: ionophores, buffers, probiotics, beta-agonists …
- Now a “new” player looking in on this (rather crowded) stage:

Bioactive peptides

Objective of this presentation

Bioactive Peptides

- What are they?
- How do they work?
- Where do they fit in?
- Can they become a tool in the feedlot?
- **Will** they … ???

The story starts with ***proteins*** …

- A familiar entity … a key nutrient
- Billions of individual proteins across all living organisms
- Ruminant feedstuffs contain thousands of specific proteins
- A **protein** is a macromolecule composed of one or more polypeptide chains of **amino acids** linked by peptide bonds, folded into a distinct 3-dimensional conformation that dictates its biological or structural function
- Typically contains **16% nitrogen** (the basis for the 6.25 multiplier used in crude protein analysis)

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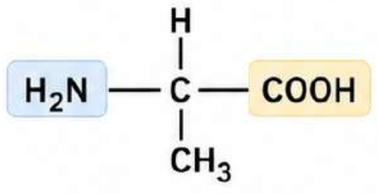
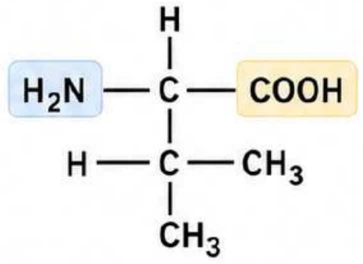
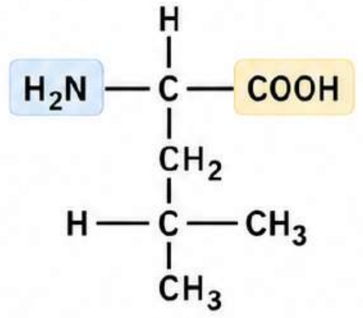


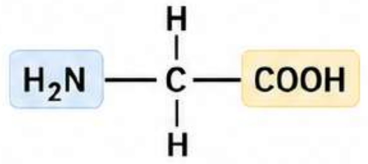
alanine
(Ala., A)



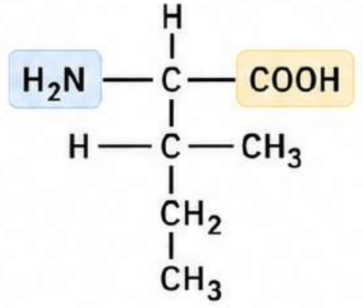
valine
(Val., V)



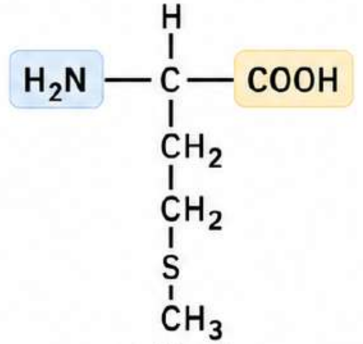
leucine
(Leu., L)



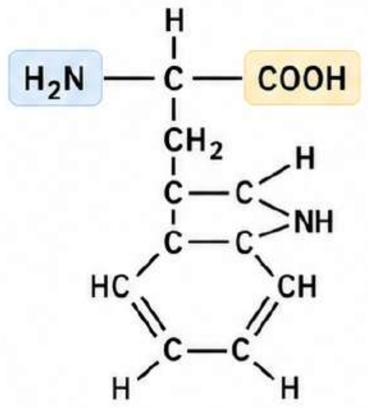
glycine
(Gly., G)



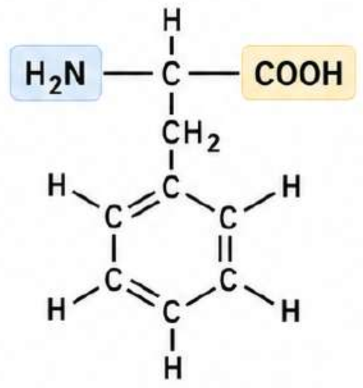
isoleucine
(Ile., I)



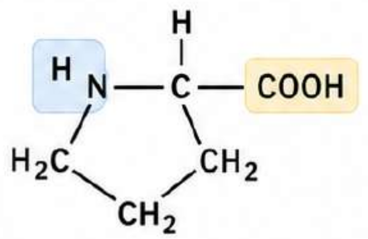
methionine
(Met., M)



tryptophan
(Try or Trp., W)



phenylalanine
(Phe., F)

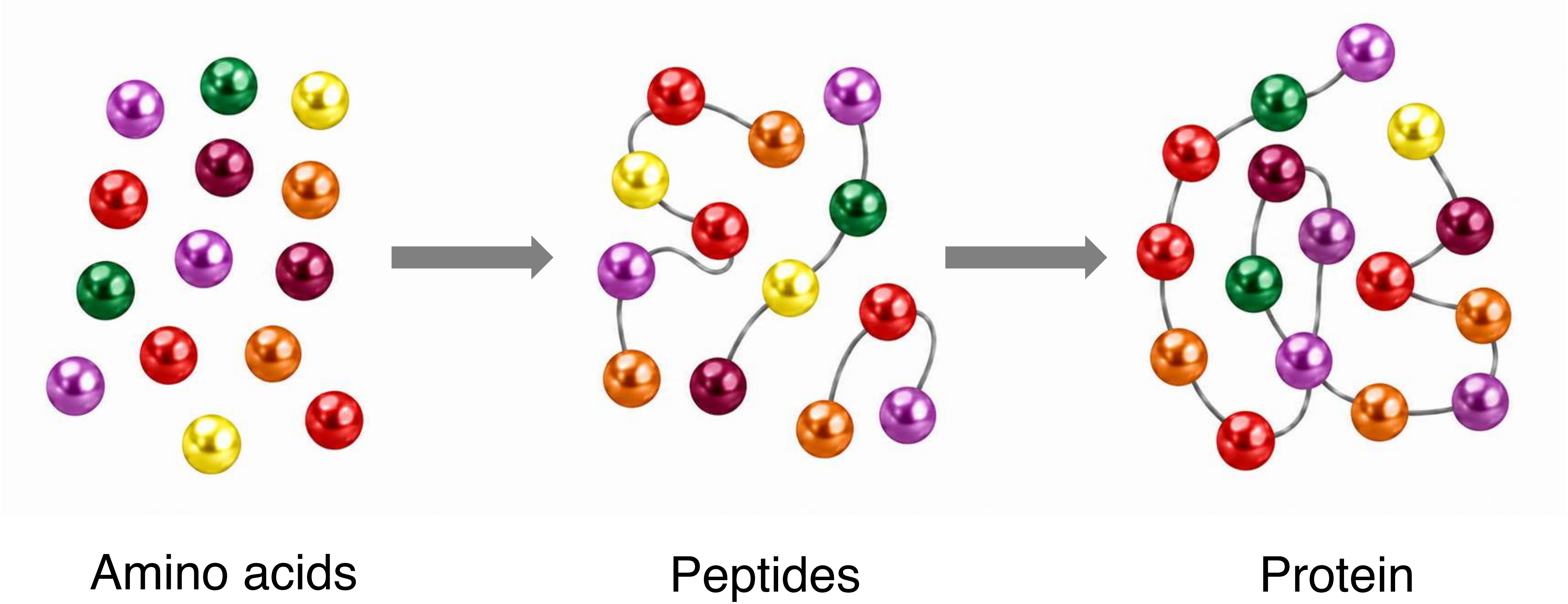


proline
(Pro., P)
an amino acid

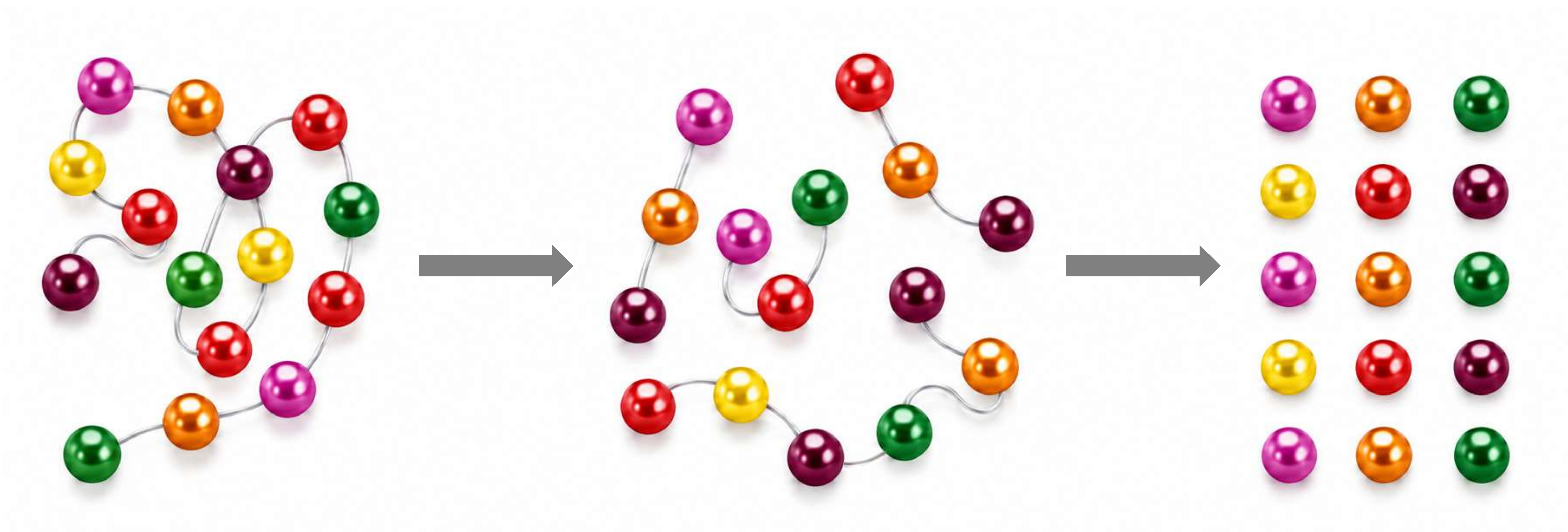
The 20 <u>standard</u> (“natural”) **amino acids**

Amino acid	Three-letter	One-letter	Amino acid	Three-letter	One-letter
Alanine	Ala	**A**	Leucine	Leu	**L**
Arginine	Arg	**R**	Lysine	Lys	**K**
Asparagine	Asn	**N**	Methionine	Met	**M**
Aspartic acid	Asp	**D**	Phenylalanine	Phe	**F**
Cysteine	Cys	**C**	Proline	Pro	**P**
Glutamine	Gln	**Q**	Serine	Ser	**S**
Glutamic acid	Glu	**E**	Threonine	Thr	**T**
Glycine	Gly	**G**	Tryptophan	Trp	**W**
Histidine	His	**H**	Tyrosine	Tyr	**Y**
Isoleucine	Ile	**I**	Valine	Val	**V**

Amino Acid to Protein



Protein Digestion

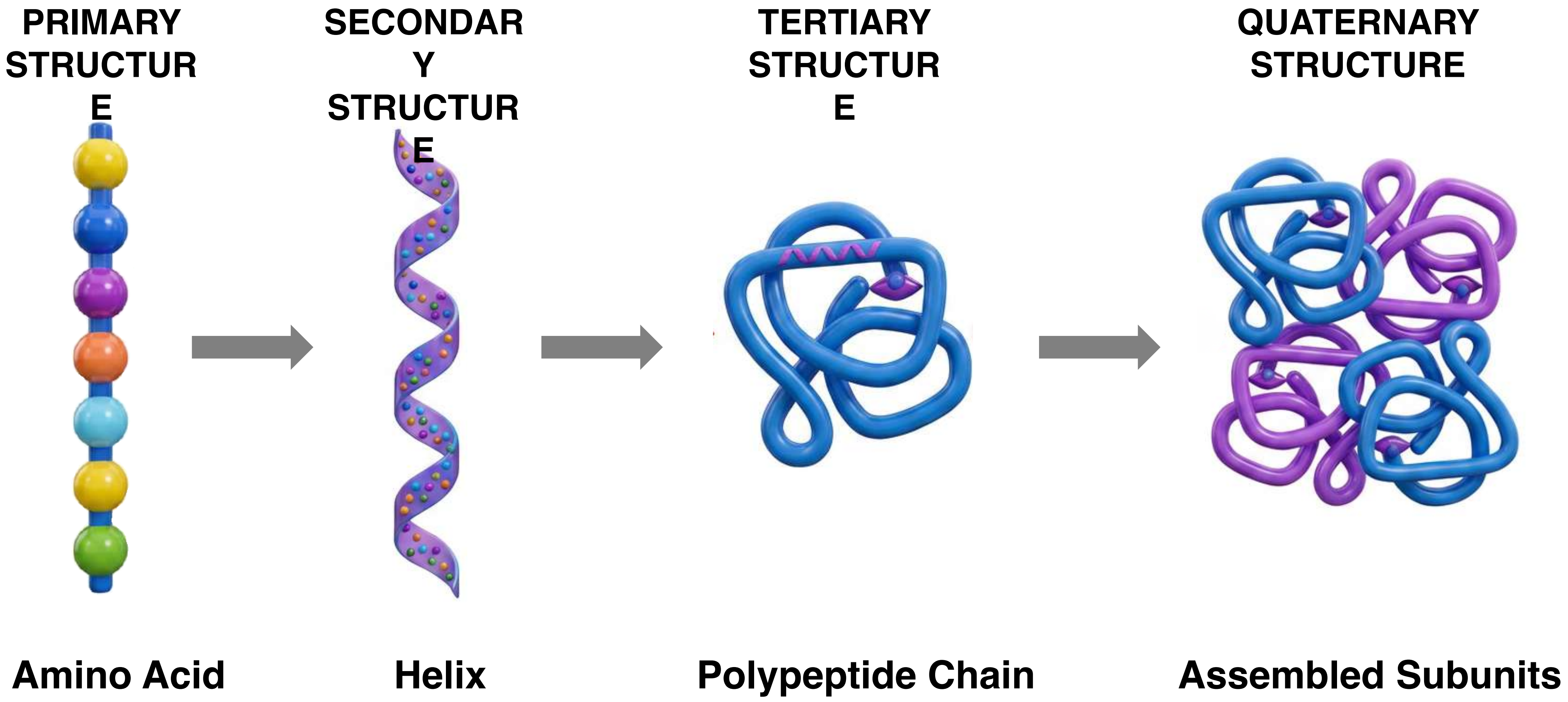


Protein

Peptides

Amino acids

Protein Structure



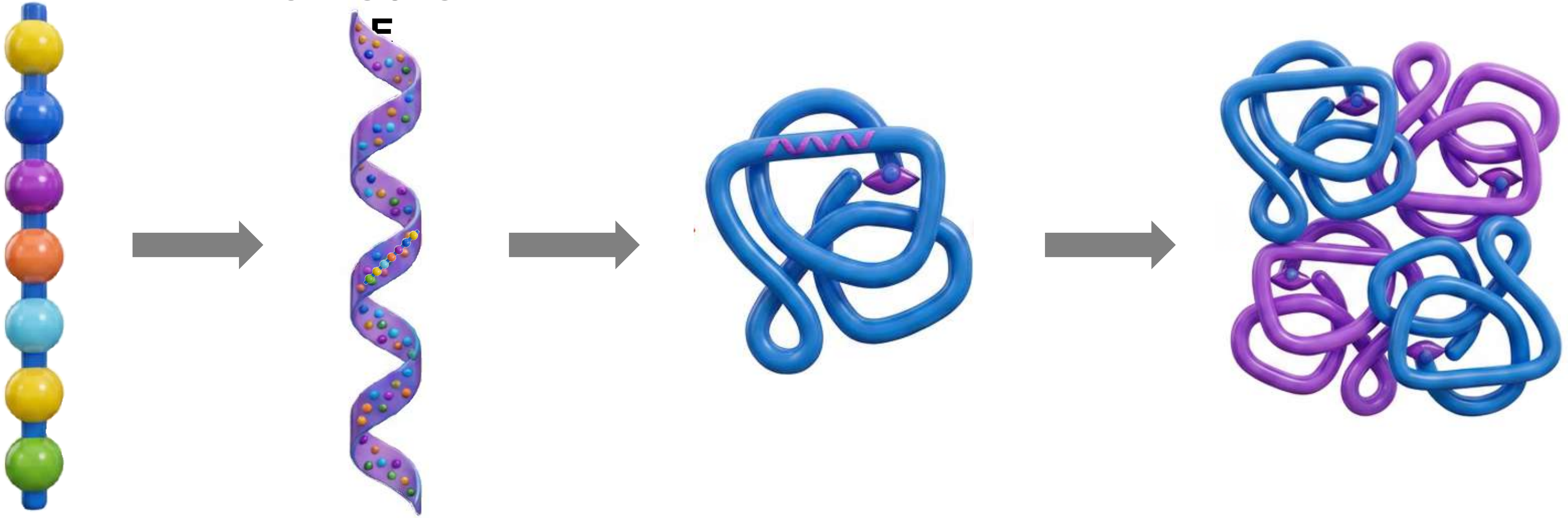
Protein Structure

PRIMARY STRUCTUR E

SECONDAR Y STRUCTUR E

TERTIARY STRUCTUR E

QUATERNARY STRUCTURE



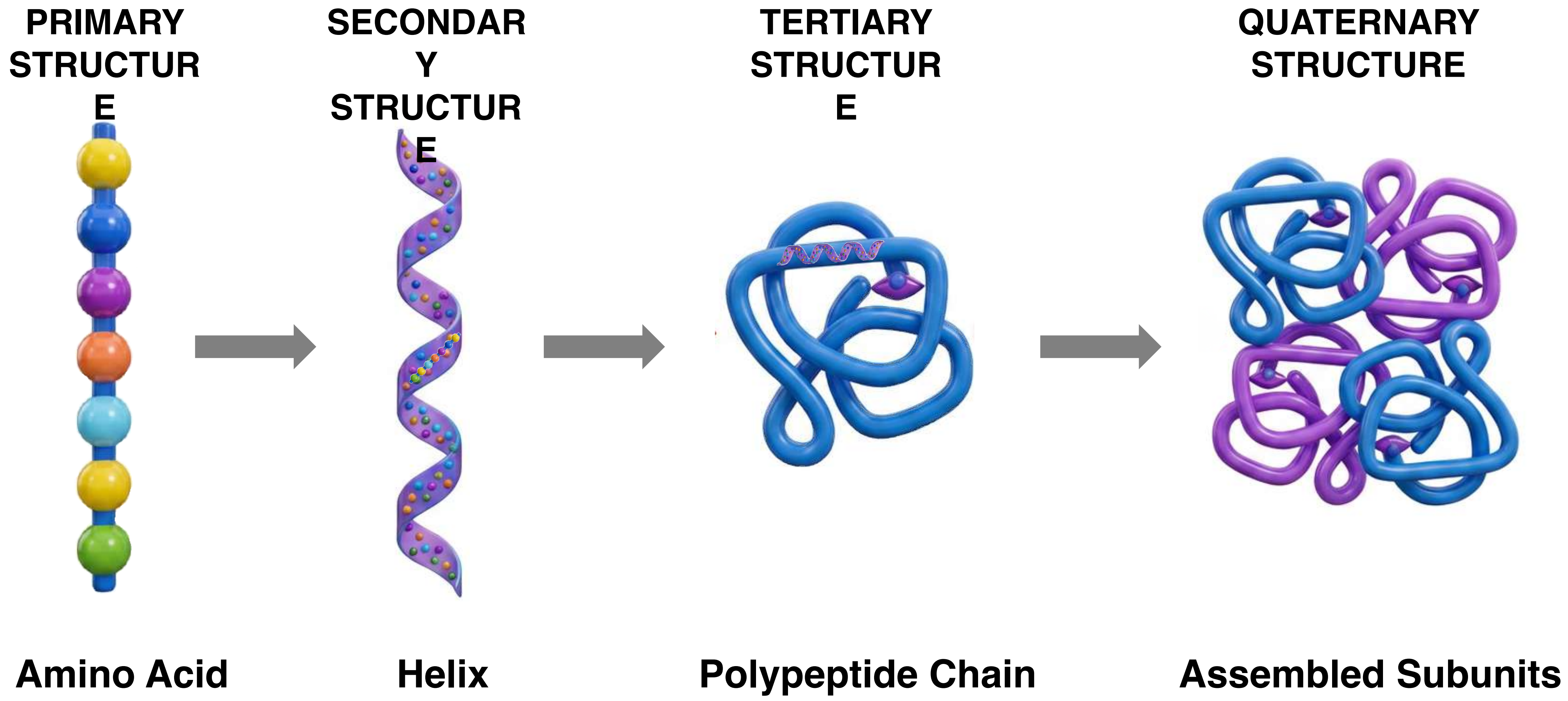
Amino Acid

Helix

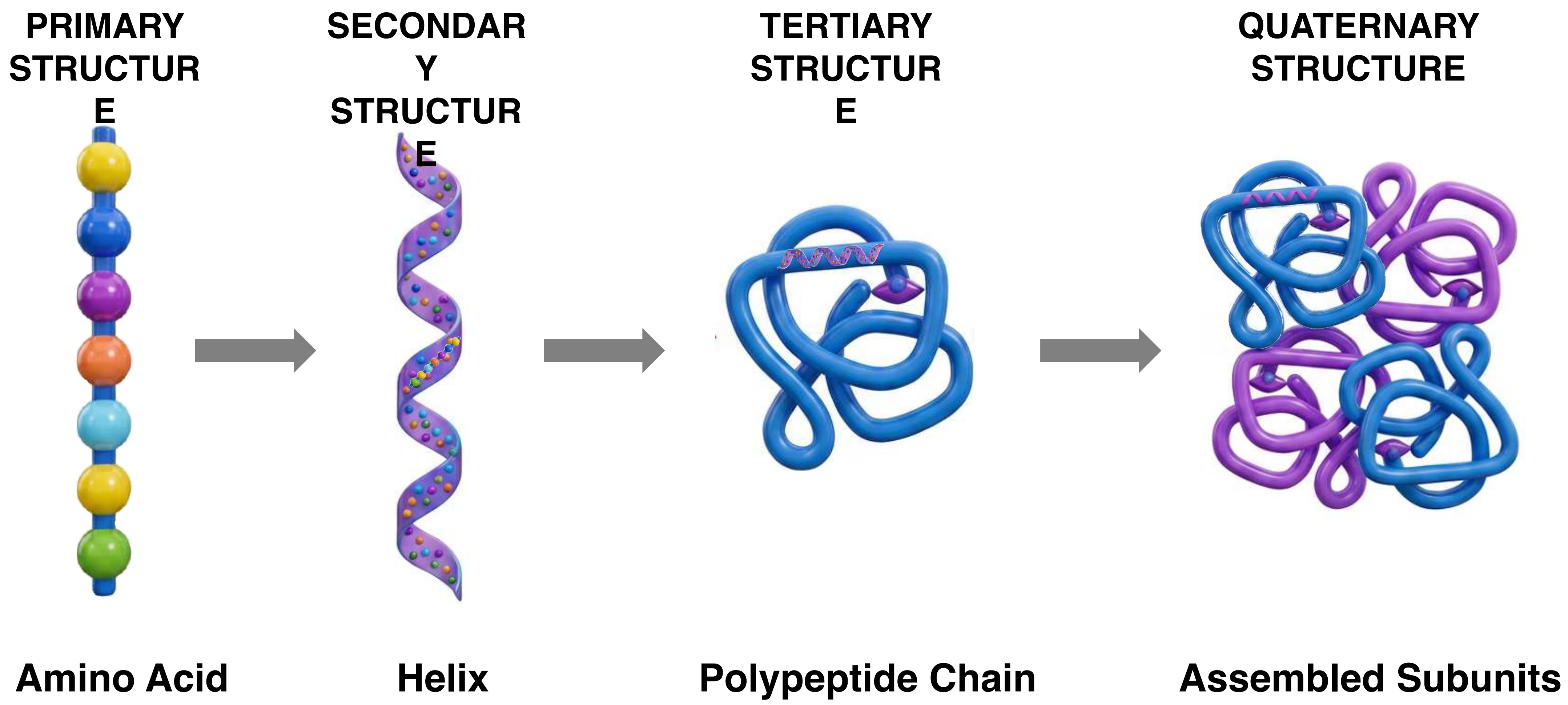
Polypeptide Chain

Assembled Subunits

Protein Structure

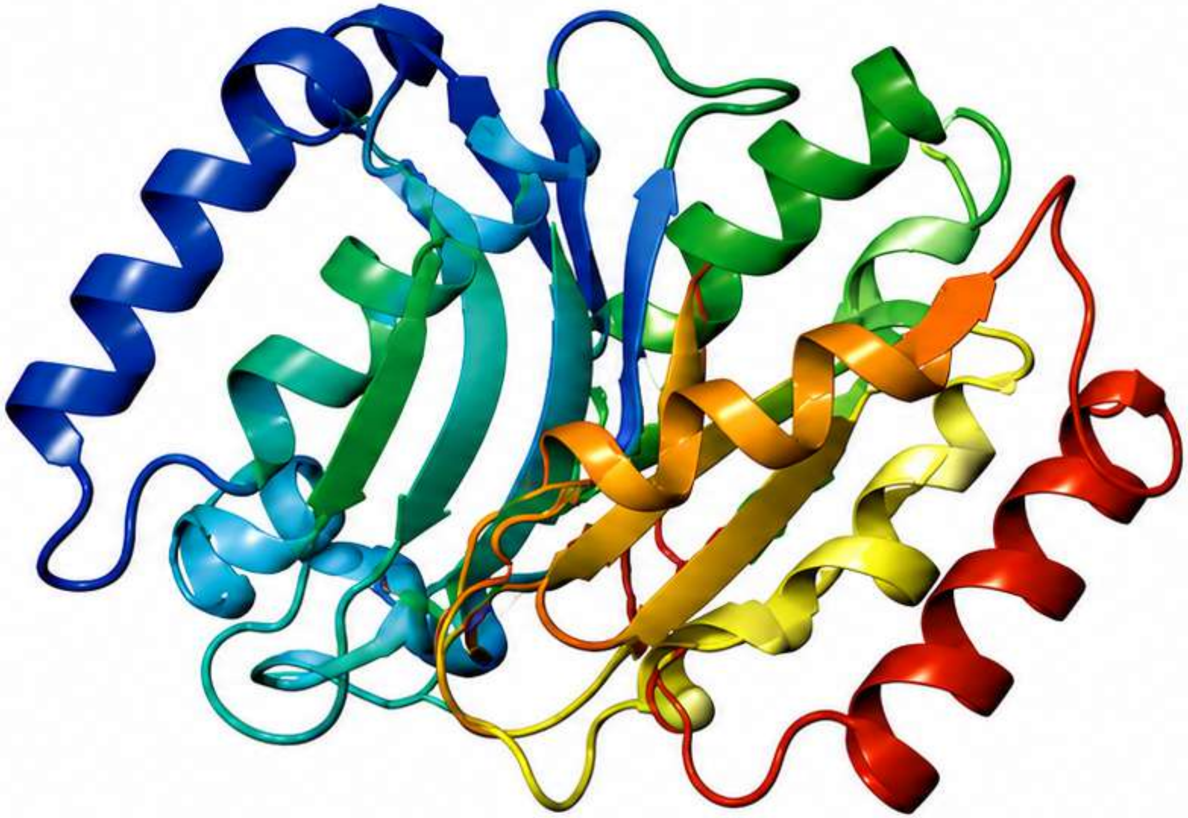


Protein Structure



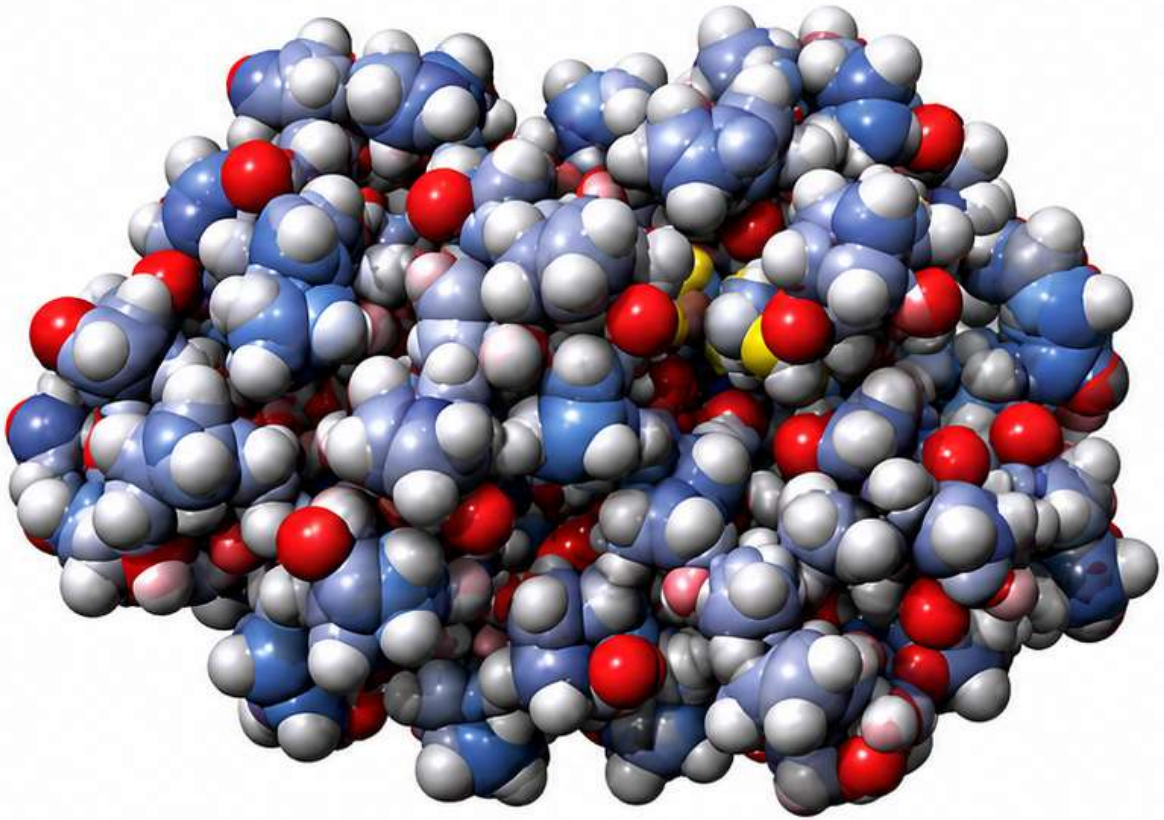
The Same Protein Shown in Two Representations

Ribbon (cartoon) representation

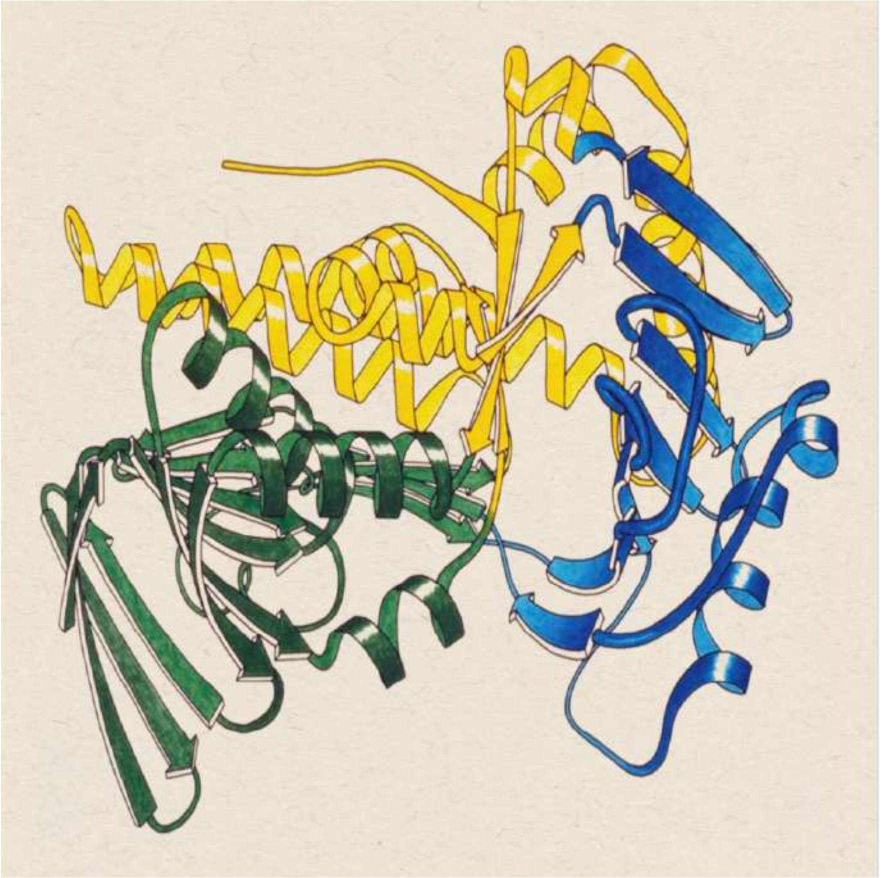
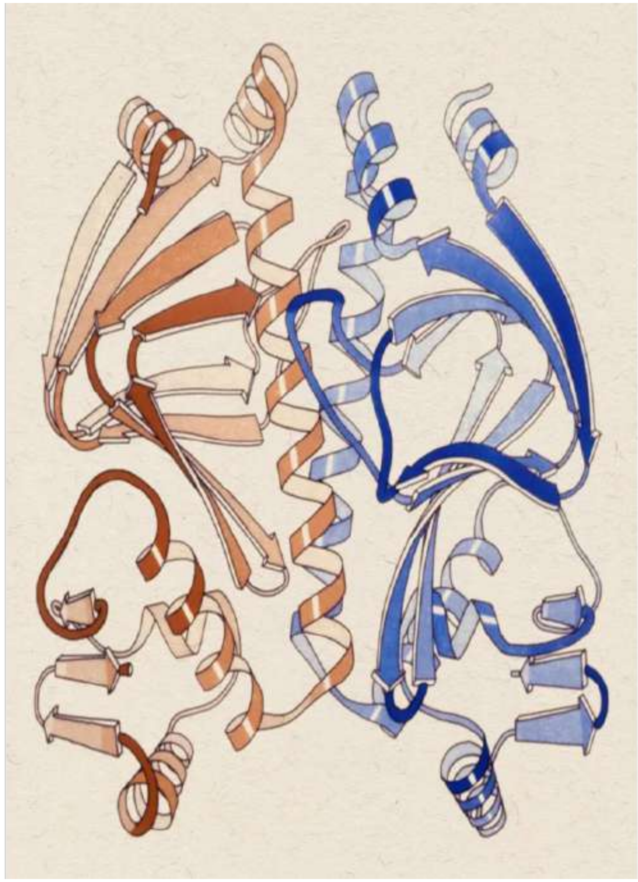
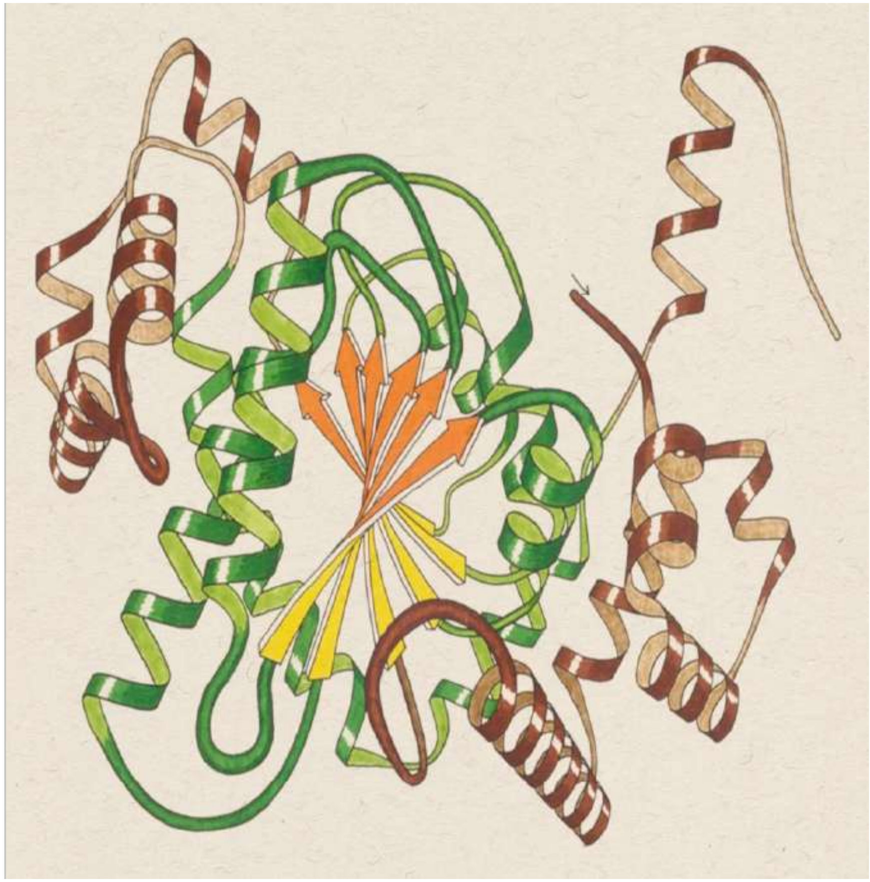


Secondary structure elements (α-helices, β-strands and loops) are visible.

Space-filling representation

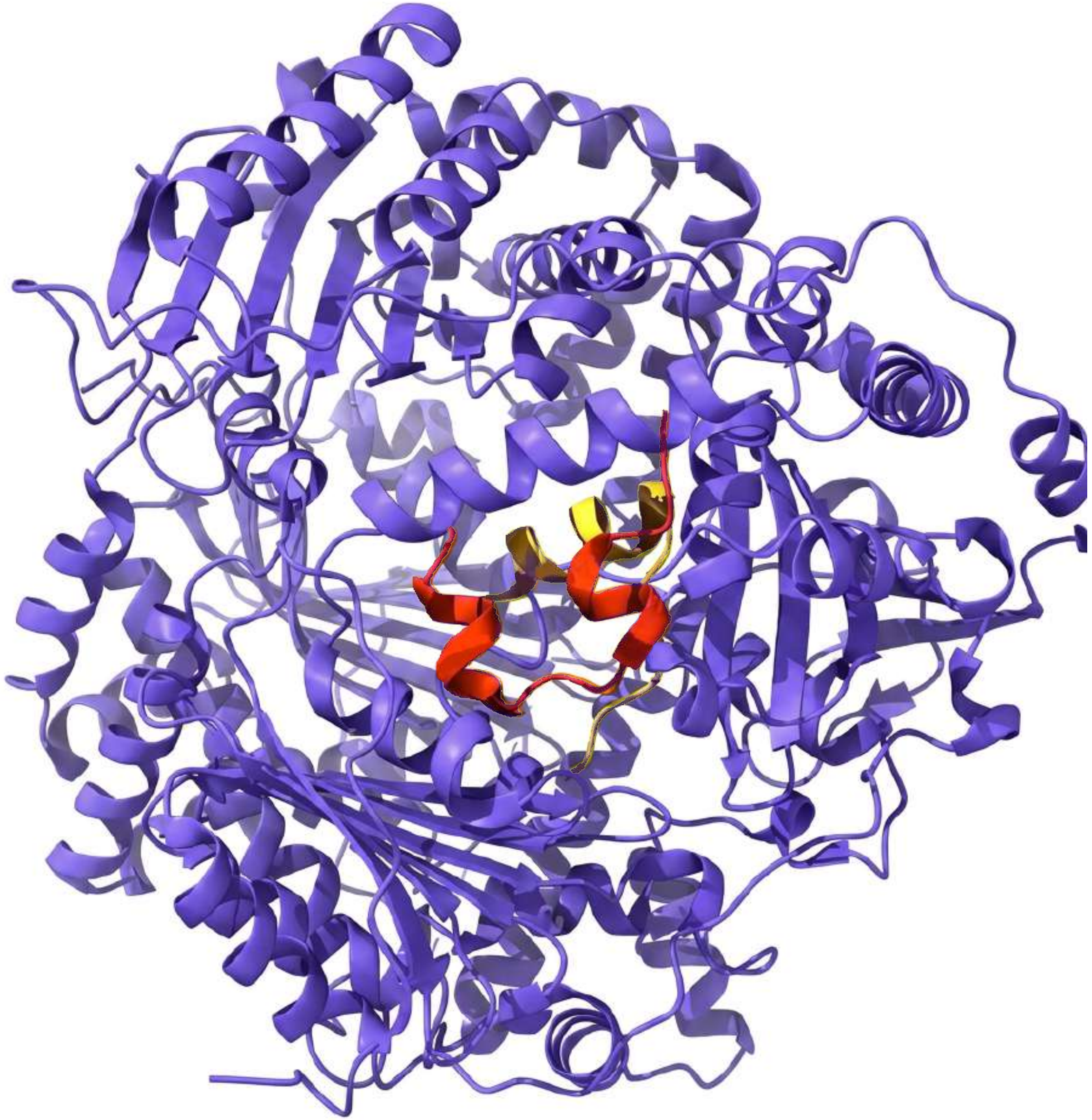


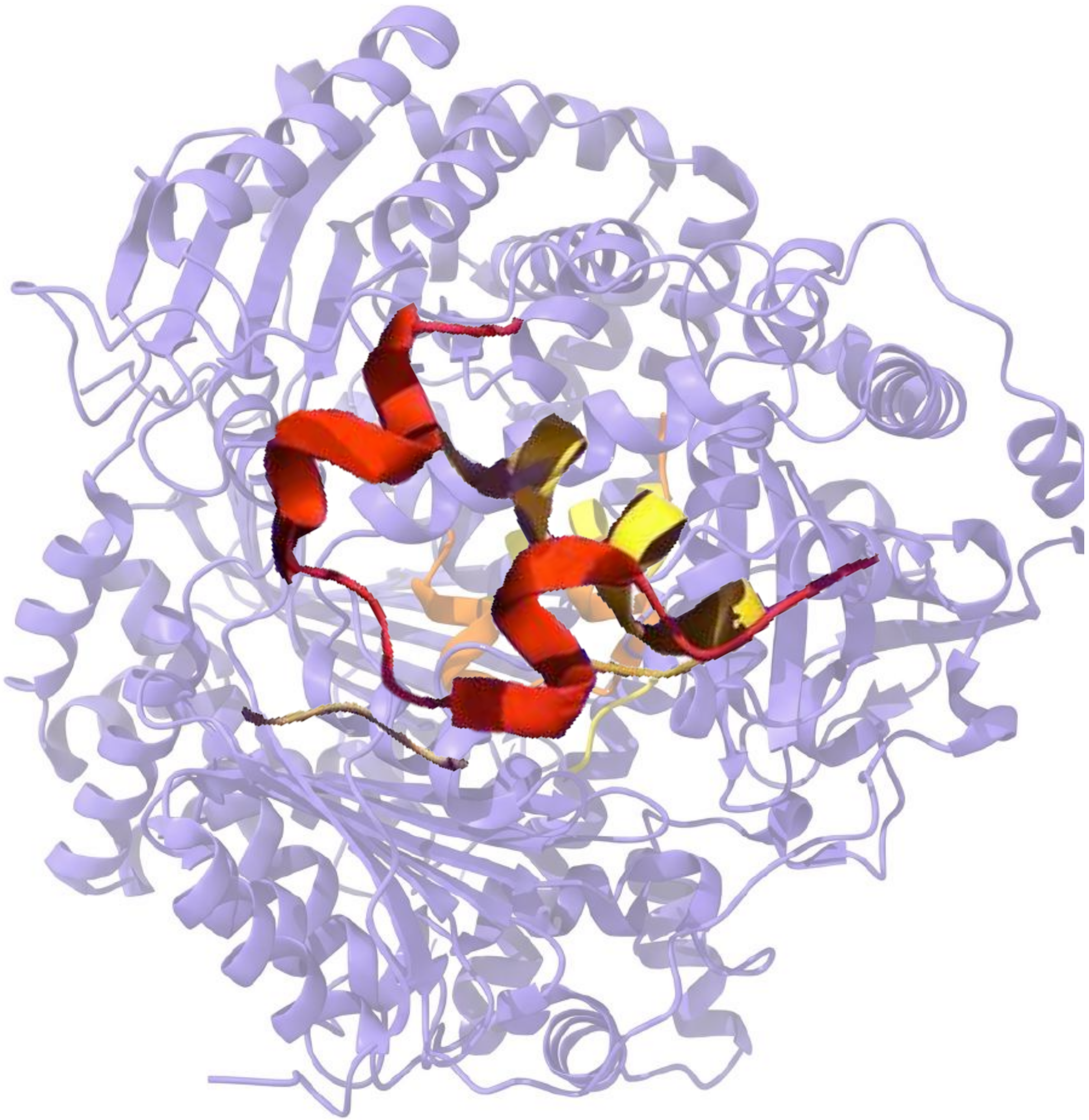
All atoms are shown as spheres, giving a sense of the protein's overall shape and surface.

What is a B*ioactive Peptide (BP)*?

- **A short chain of amino acids** (typically **2 – 20**, sometimes up to 50 amino acids)
- **Hidden ("encrypted") within a larger protein**
- **Inactive while part of the intact protein**
- **Released** by enzymatic hydrolysis (digestion, fermentation, or food processing)
- Once released, it can **interact with specific receptors or enzymes**
- Can influence **physiology beyond simple nutrition**

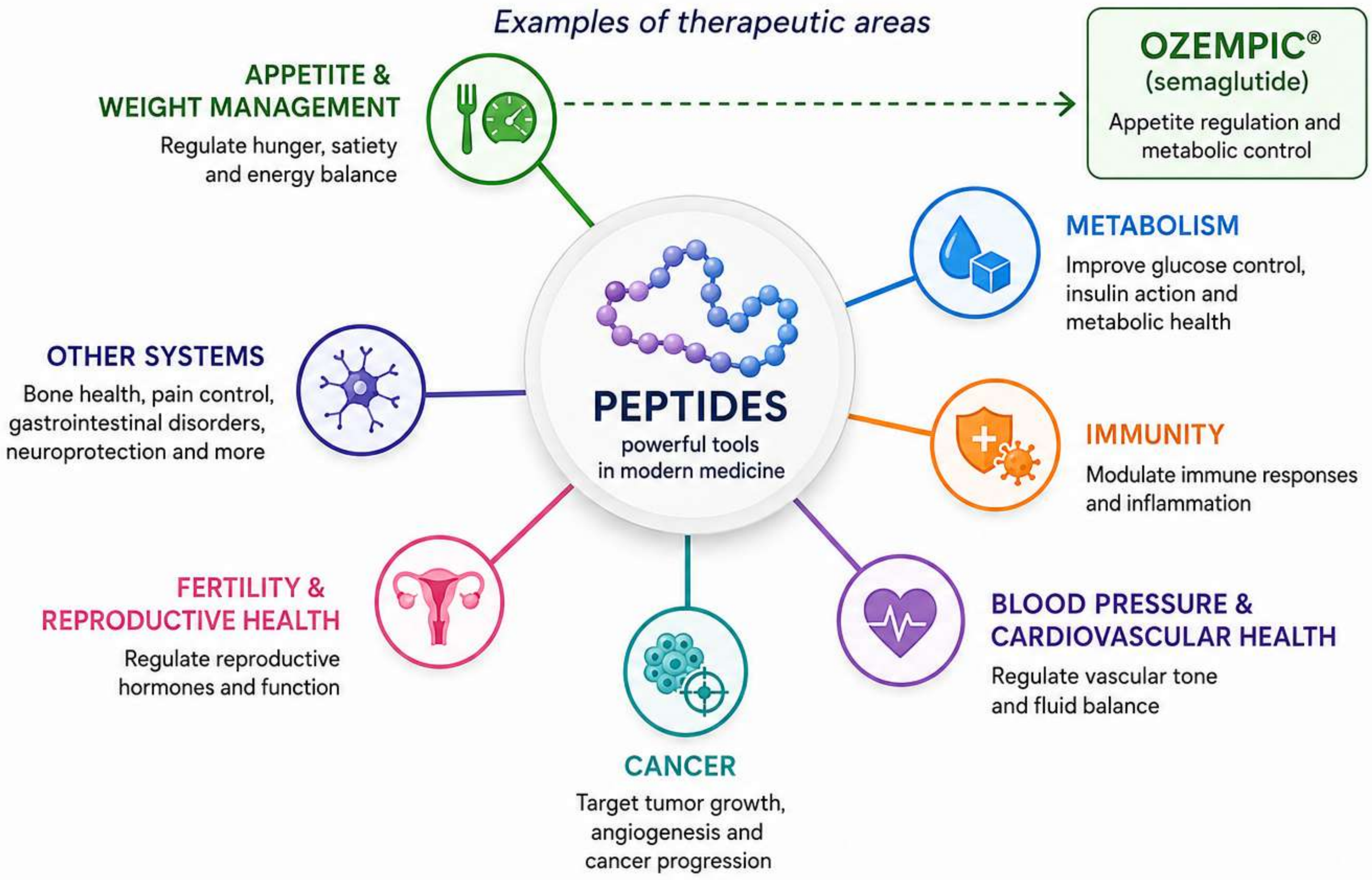




BP: from discovery to modern therapeutic

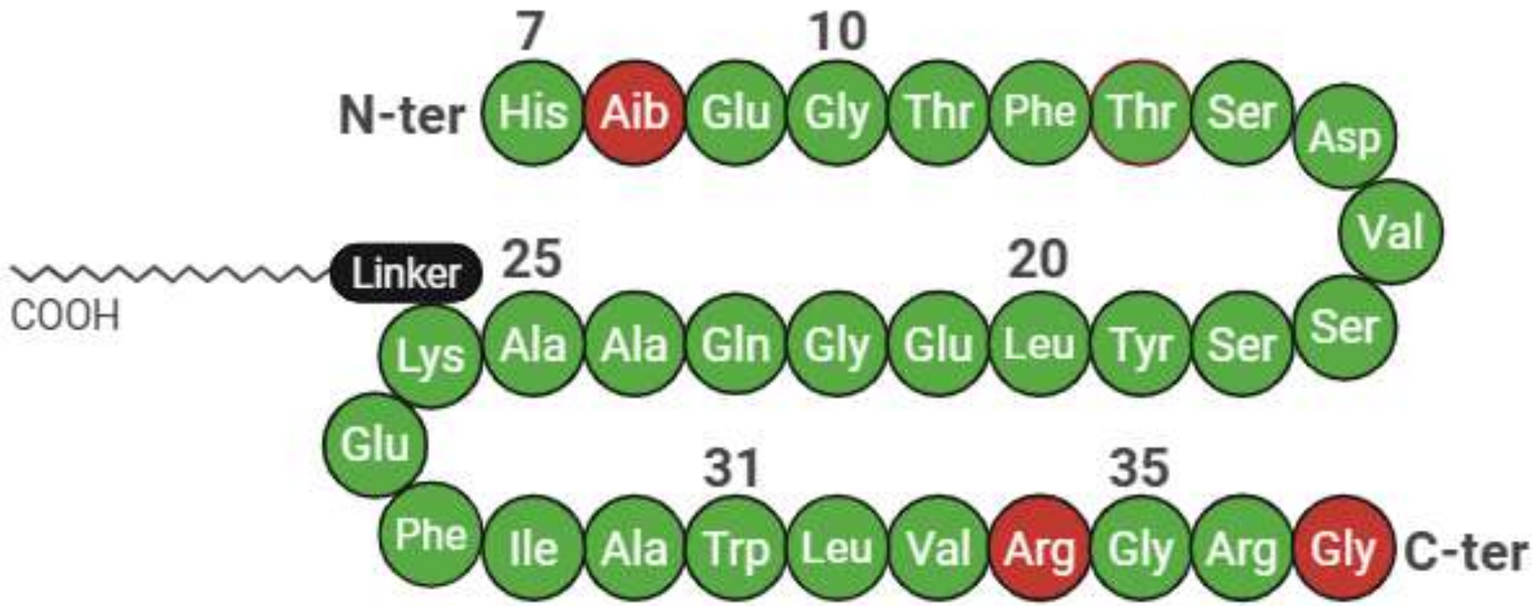
- **1921 – Insulin**: the first peptide used successfully as a medicine
- **Following decades**, many naturally occurring peptides were discovered
- **Today**, peptides are used as ***biological signalling molecules*** to target appetite, metabolism, immunity, blood pressure, fertility, cancer and many other physiological systems … in humans
- **One of the best-known examples today: …….**

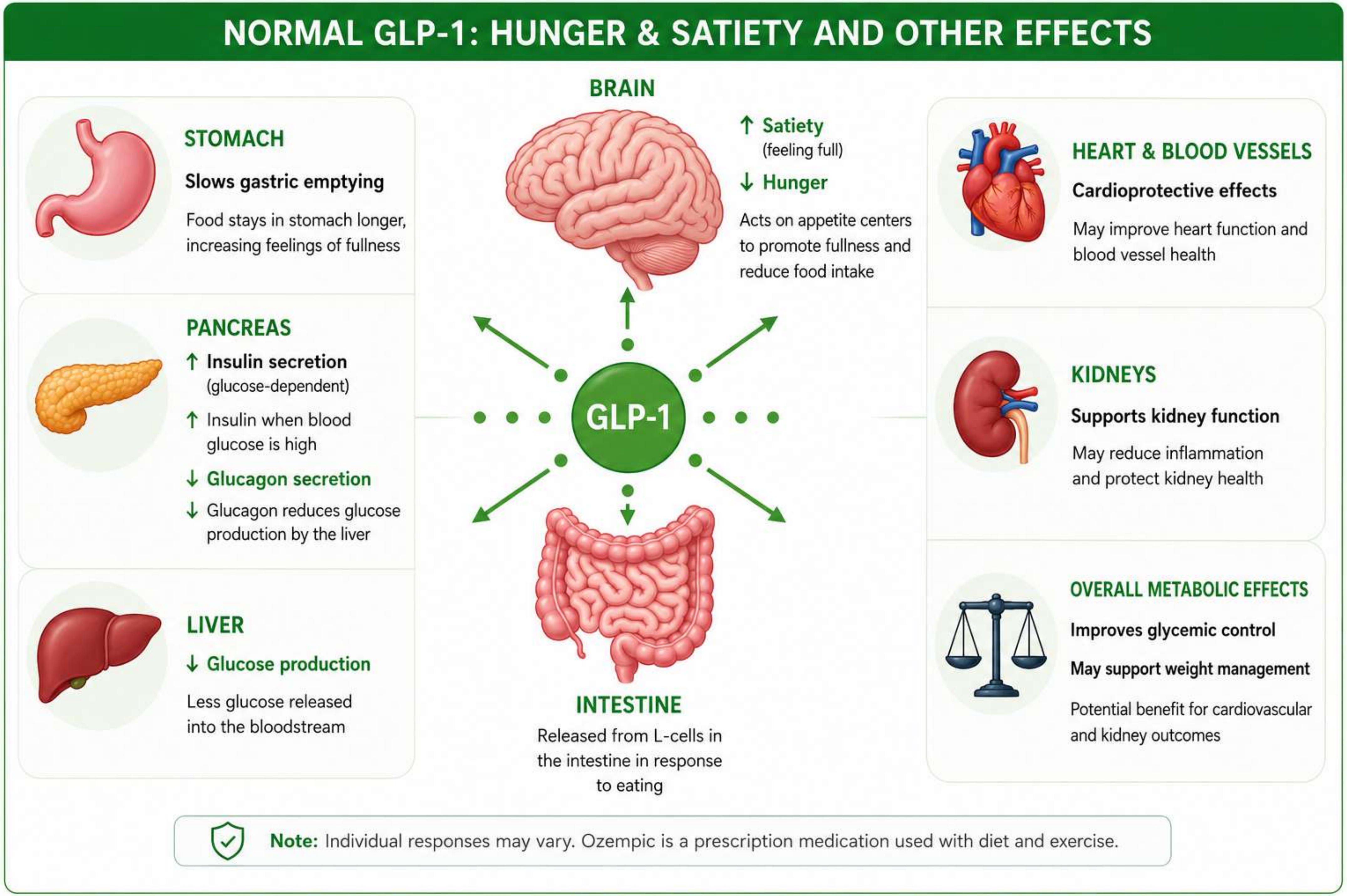
Peptides are used to target many physiological systems

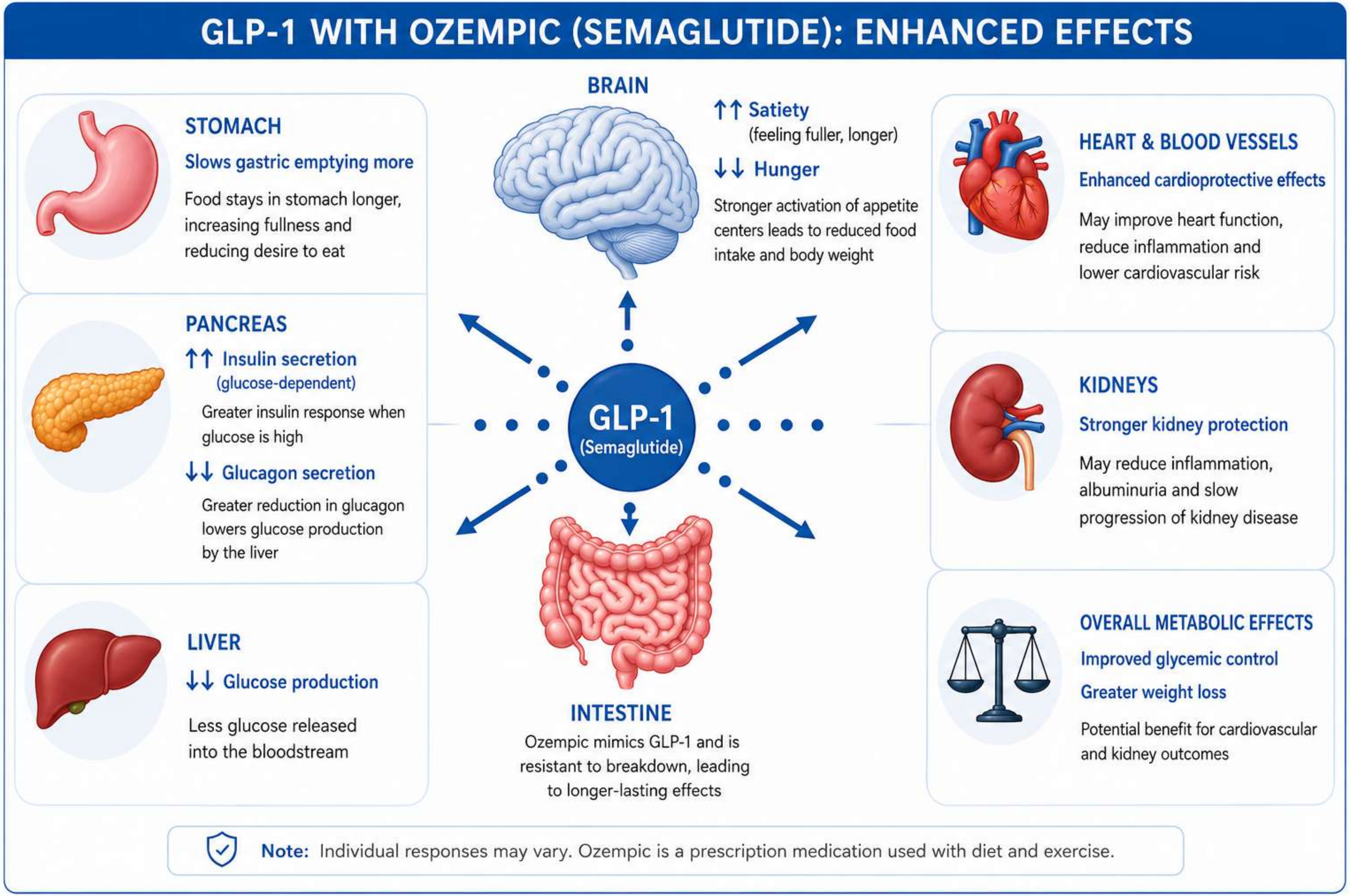



OZEMPIC®
(semaglutide) injection
For Single Patient Use Only
0
mg

Ozempic is a peptide … a bioactive peptide:



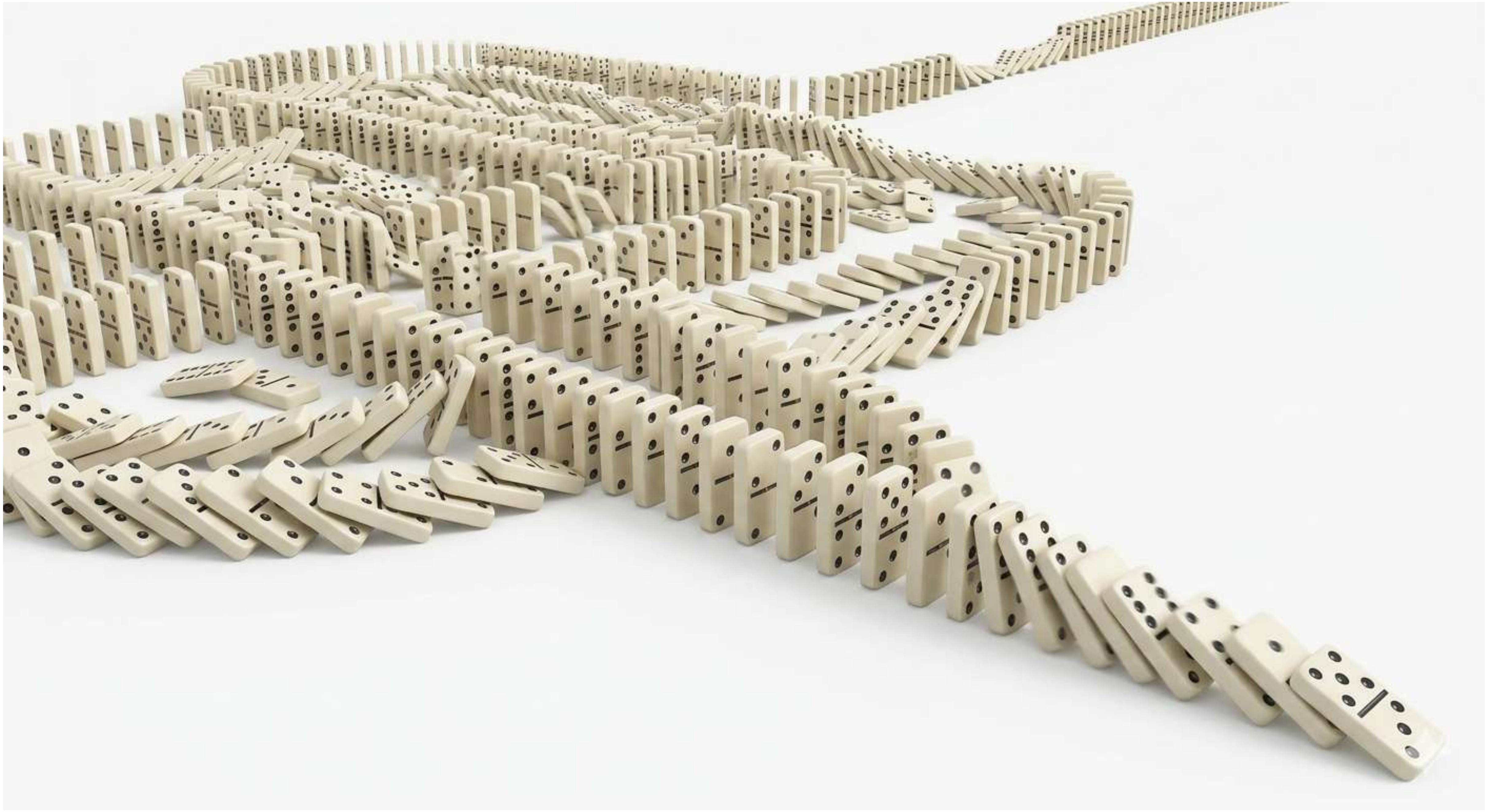

NORMAL GLP-1: HUNGER & SATIETY AND OTHER EFFECTS
STOMACH
Slows gastric emptying
Food stays in stomach longer, increasing feelings of fullness
PANCREAS
↑ Insulin secretion (glucose-dependent)
↑ Insulin when blood glucose is high
↓ Glucagon secretion
↓ Glucagon reduces glucose production by the liver
LIVER
↓ Glucose production
Less glucose released into the bloodstream
BRAIN
↑ Satiety (feeling full)
↓ Hunger
Acts on appetite centers to promote fullness and reduce food intake
GLP-1
INTESTINE
Released from L-cells in the intestine in response to eating
HEART & BLOOD VESSELS
Cardioprotective effects
May improve heart function and blood vessel health
KIDNEYS
Supports kidney function
May reduce inflammation and protect kidney health
OVERALL METABOLIC EFFECTS
Improves glycemic control
May support weight management
Potential benefit for cardiovascular and kidney outcomes
Note: Individual responses may vary. Ozempic is a prescription medication used with diet and exercise.


GLP-1 WITH OZEMPIC (SEMAGLUTIDE): ENHANCED EFFECTS
STOMACH
Slows gastric emptying more
Food stays in stomach longer, increasing fullness and reducing desire to eat
BRAIN
↑↑ Satiety
(feeling fuller, longer)
↓↓ Hunger
Stronger activation of appetite centers leads to reduced food intake and body weight
HEART & BLOOD VESSELS
Enhanced cardioprotective effects
May improve heart function, reduce inflammation and lower cardiovascular risk
PANCREAS
↑↑ Insulin secretion
(glucose-dependent)
Greater insulin response when glucose is high
↓↓ Glucagon secretion
Greater reduction in glucagon lowers glucose production by the liver
GLP-1
(Semaglutide)
KIDNEYS
Stronger kidney protection
May reduce inflammation, albuminuria and slow progression of kidney disease
LIVER
↓↓ Glucose production
Less glucose released into the bloodstream
INTESTINE
Ozempic mimics GLP-1 and is resistant to breakdown, leading to longer-lasting effects
OVERALL METABOLIC EFFECTS
Improved glycemic control
Greater weight loss
Potential benefit for cardiovascular and kidney outcomes
Note: Individual responses may vary. Ozempic is a prescription medication used with diet and exercise.

How can *milligrams* make such a big difference?

- Dose size: 1.0 mg per week
- Bioactive peptides act as signals – not as nutrients
- Many bioactive peptides act as signalling molecules; they produce biological effects at very low doses because their signals are amplified inside cells.
- The secret: **signal amplification**

… through a cellular cascade … “domino effect”



What do we want in the feedlot?

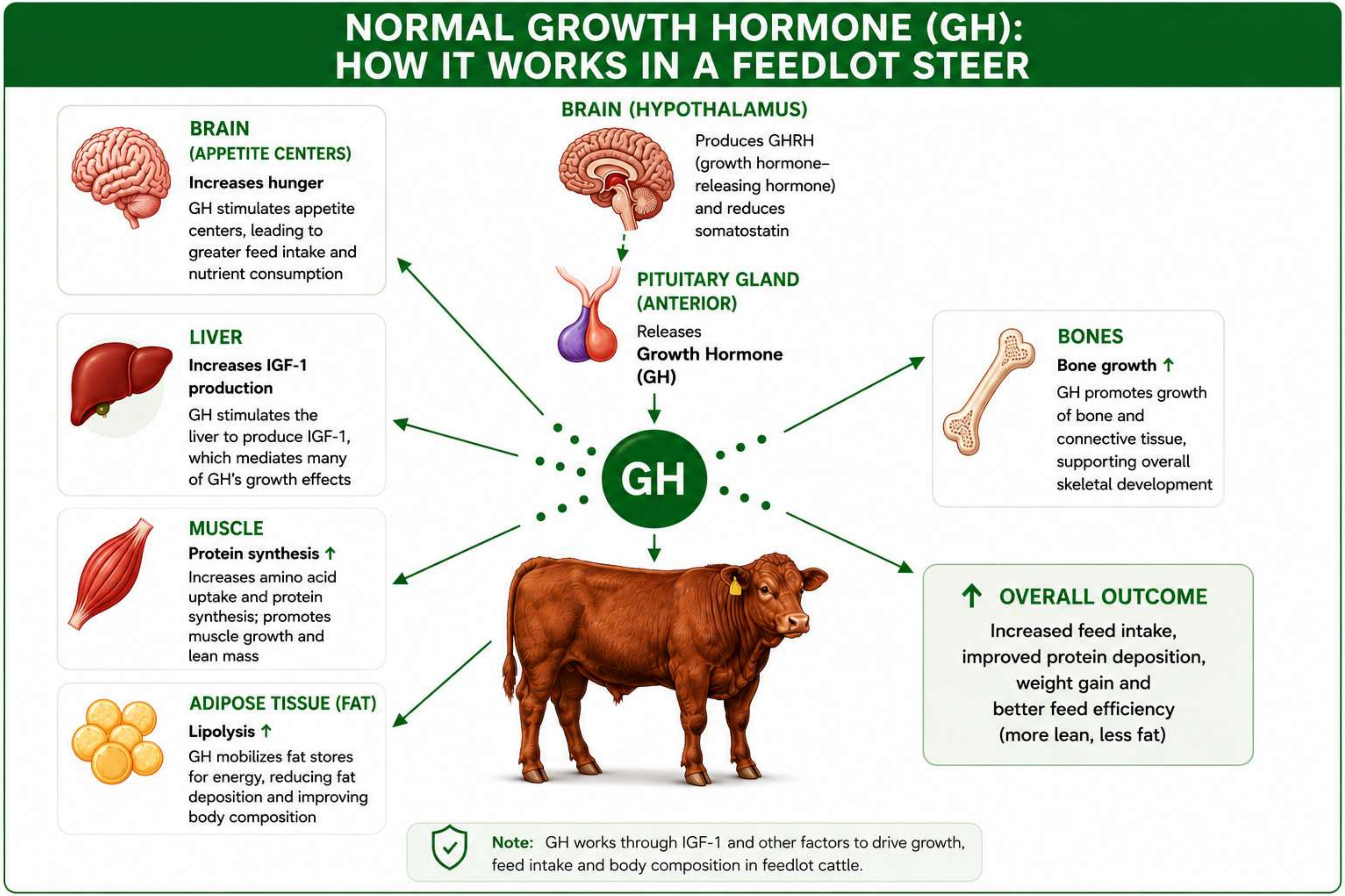
- Exactly the opposite!
- We’re looking for:
  - Appetite ↑
  - Weight gain ↑

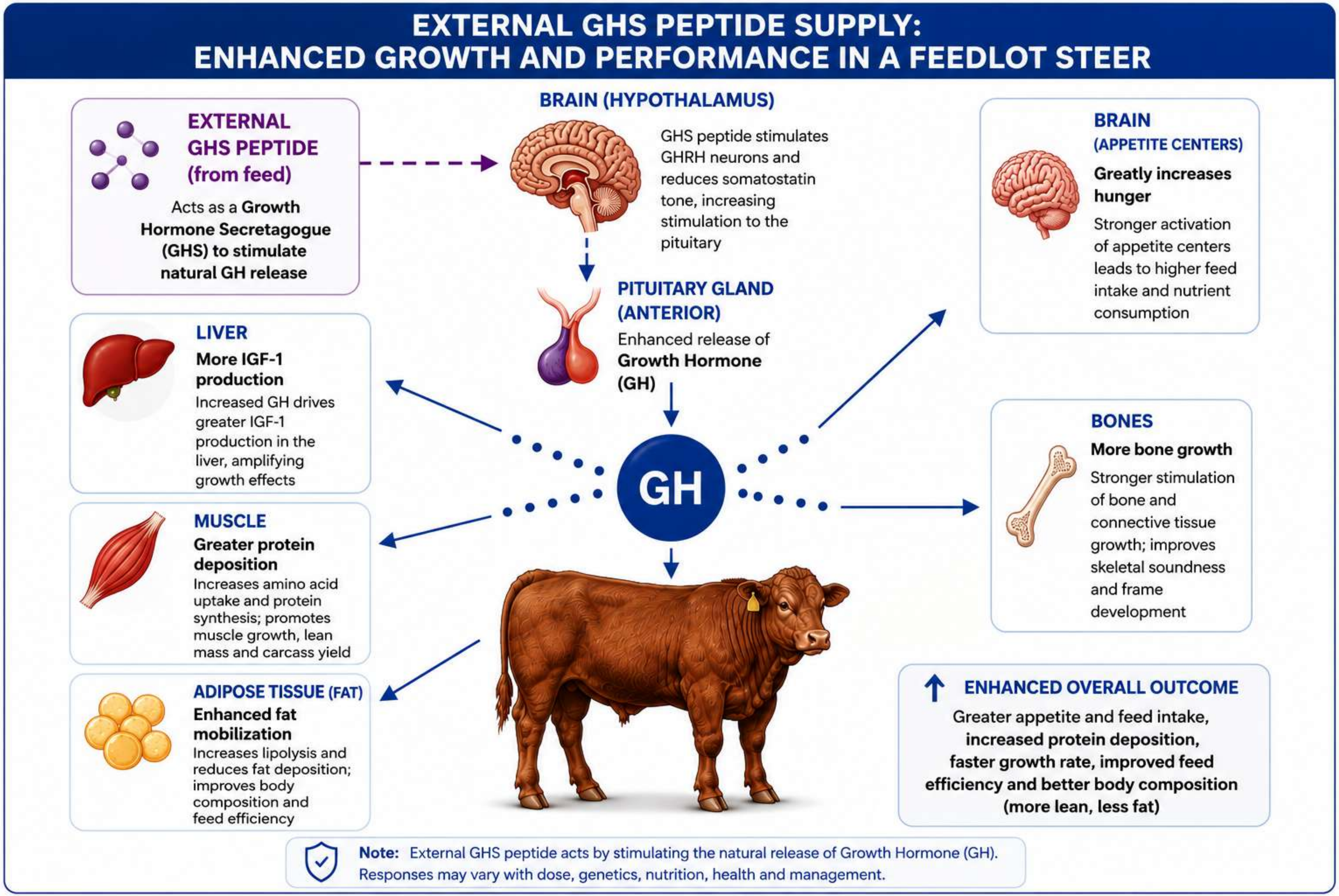
  - And while we’re at it:
    - More protein, less fat – in gain
    - Improved feed efficiency ...

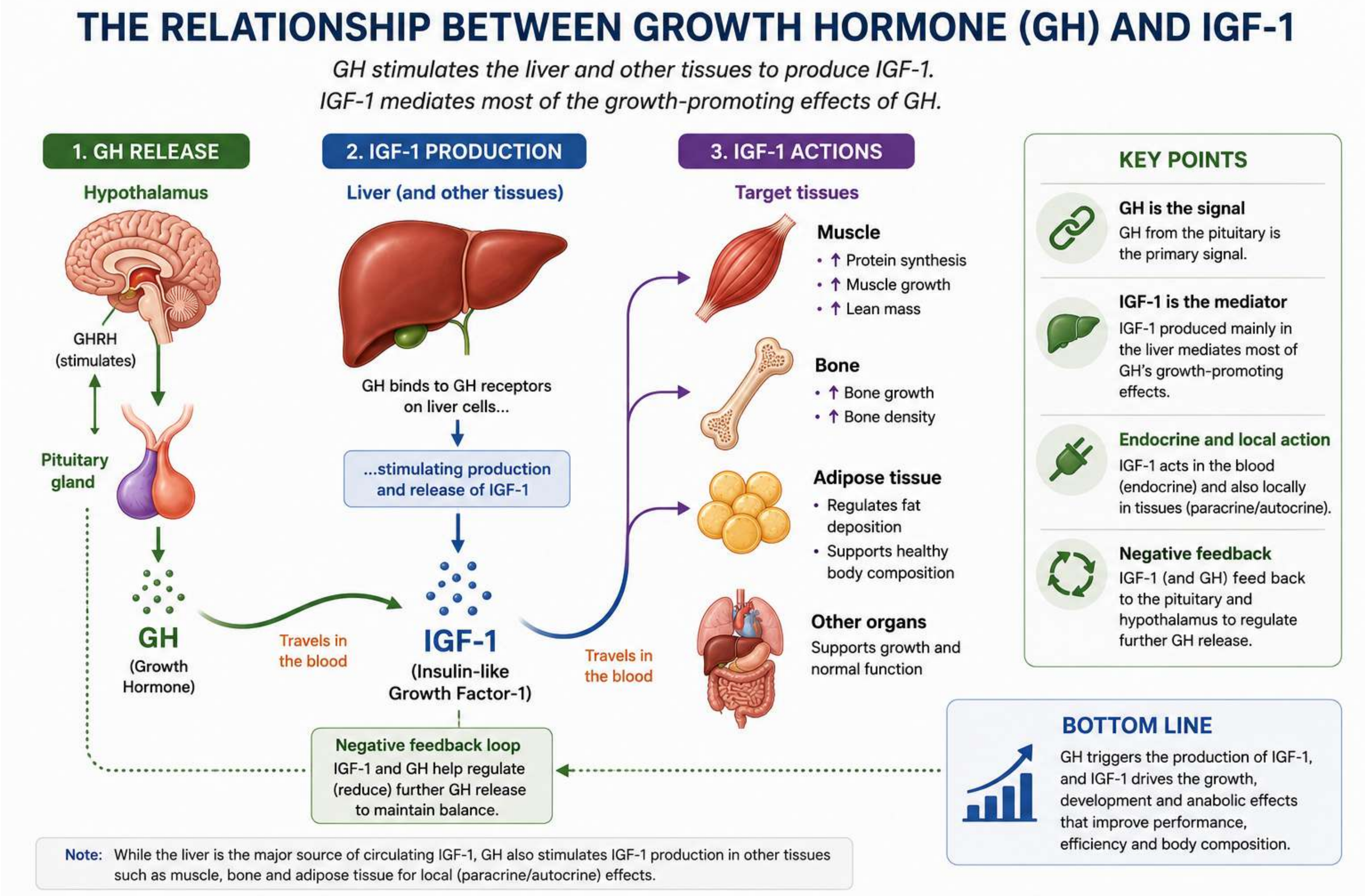
So, let's consider a hypothetical alternative:

- Suppose we have a peptide, similar to *Ozempic*, but working in "the opposite direction" …
- … affecting **growth hormone** … growth hormone ↑

- Growth hormone secretagogue (GHS)


NORMAL GROWTH HORMONE (GH):
HOW IT WORKS IN A FEEDLOT STEER
BRAIN (HYPOTHALAMUS)
Produces GHRH (growth hormone–releasing hormone) and reduces somatostatin
PITUITARY GLAND (ANTERIOR)
Releases Growth Hormone (GH)
GH
BRAIN (APPETITE CENTERS)
Increases hunger
GH stimulates appetite centers, leading to greater feed intake and nutrient consumption
LIVER
Increases IGF-1 production
GH stimulates the liver to produce IGF-1, which mediates many of GH's growth effects
MUSCLE
Protein synthesis ↑
Increases amino acid uptake and protein synthesis; promotes muscle growth and lean mass
ADIPOSE TISSUE (FAT)
Lipolysis ↑
GH mobilizes fat stores for energy, reducing fat deposition and improving body composition
BONES
Bone growth ↑
GH promotes growth of bone and connective tissue, supporting overall skeletal development
↑ OVERALL OUTCOME
Increased feed intake, improved protein deposition, weight gain and better feed efficiency (more lean, less fat)
Note: GH works through IGF-1 and other factors to drive growth, feed intake and body composition in feedlot cattle.


EXTERNAL GHS PEPTIDE SUPPLY:
ENHANCED GROWTH AND PERFORMANCE IN A FEEDLOT STEER
EXTERNAL GHS PEPTIDE (from feed)
Acts as a Growth Hormone Secretagogue (GHS) to stimulate natural GH release
BRAIN (HYPOTHALAMUS)
GHS peptide stimulates GHRH neurons and reduces somatostatin tone, increasing stimulation to the pituitary
PITUITARY GLAND (ANTERIOR)
Enhanced release of Growth Hormone (GH)
GH
BRAIN (APPETITE CENTERS)
Greatly increases hunger
Stronger activation of appetite centers leads to higher feed intake and nutrient consumption
LIVER
More IGF-1 production
Increased GH drives greater IGF-1 production in the liver, amplifying growth effects
MUSCLE
Greater protein deposition
Increases amino acid uptake and protein synthesis; promotes muscle growth, lean mass and carcass yield
ADIPOSE TISSUE (FAT)
Enhanced fat mobilization
Increases lipolysis and reduces fat deposition; improves body composition and feed efficiency
BONES
More bone growth
Stronger stimulation of bone and connective tissue growth; improves skeletal soundness and frame development
ENHANCED OVERALL OUTCOME
Greater appetite and feed intake, increased protein deposition, faster growth rate, improved feed efficiency and better body composition (more lean, less fat)
Note: External GHS peptide acts by stimulating the natural release of Growth Hormone (GH). Responses may vary with dose, genetics, nutrition, health and management.


THE RELATIONSHIP BETWEEN GROWTH HORMONE (GH) AND IGF-1
GH stimulates the liver and other tissues to produce IGF-1.
IGF-1 mediates most of the growth-promoting effects of GH.
1. GH RELEASE
Hypothalamus
GHRH
(stimulates)
Pituitary
gland
GH
(Growth
Hormone)
Travels in
the blood
2. IGF-1 PRODUCTION
Liver (and other tissues)
GH binds to GH receptors
on liver cells...
...stimulating production
and release of IGF-1
IGF-1
(Insulin-like
Growth Factor-1)
Travels in
the blood
Negative feedback loop
IGF-1 and GH help regulate
(reduce) further GH release
to maintain balance.
3. IGF-1 ACTIONS
Target tissues
Muscle
• ↑ Protein synthesis
• ↑ Muscle growth
• ↑ Lean mass
Bone
• ↑ Bone growth
• ↑ Bone density
Adipose tissue
• Regulates fat deposition
• Supports healthy body composition
Other organs
Supports growth and normal function
KEY POINTS
GH is the signal
GH from the pituitary is the primary signal.
IGF-1 is the mediator
IGF-1 produced mainly in the liver mediates most of GH's growth-promoting effects.
Endocrine and local action
IGF-1 acts in the blood (endocrine) and also locally in tissues (paracrine/autocrine).
Negative feedback
IGF-1 (and GH) feed back to the pituitary and hypothalamus to regulate further GH release.
BOTTOM LINE
GH triggers the production of IGF-1, and IGF-1 drives the growth, development and anabolic effects that improve performance, efficiency and body composition.
Note: While the liver is the major source of circulating IGF-1, GH also stimulates IGF-1 production in other tissues such as muscle, bone and adipose tissue for local (paracrine/autocrine) effects.

Bioactive Peptides: Many Possible Biological Targets

Influencing More Than Just Growth

RUMEN FERMENTATION

- Modulate microbial populations
- Improve fermentation efficiency
- Influence VFA production
- Support rumen wall health

IMMUNITY

- Modulate innate and adaptive immune responses
- Enhance disease resistance
- Support immune balance

GUT HEALTH

- Strengthen gut barrier function
- Enhance nutrient absorption
- Support gut repair
- Promote overall gut health

INFLAMMATION

- Regulate cytokine signaling
- Reduce excessive inflammation
- Support tissue recovery

ANTIOXIDANT DEFENSE

- Neutralize reactive oxygen species
- Reduce oxidative stress
- Support cells during heat stress or disease

STRESS RESILIENCE

- Improve resilience to physiological stress
- Support adaptation to heat, transport and other stressors

Bioactive peptides may influence multiple physiological systems—not just growth.
The specific response depends on the peptide, its target receptor, dose, delivery and bioavailability.

Finding a *useful* bioactive peptide

- Billions of unique proteins in nature
- Proteins contain, on average, **300** to **400 amino acids (AAs)**, ranging from about **20** to over **3,000 AAs**
- How are useful bioactive peptides discovered?

Approach 1 – Discovery (Bottom-up)

Protein source

↓

Enzymatic hydrolysis

↓

Hundreds or thousands of peptides

↓

Screen for biological activity

↓

Identify the active peptide(s)

Approach 1 – Discovery (Bottom-up)

Advantages

- Unbiased
- Can discover completely unexpected BPs

Limitations

- Slow
- Many false leads
- Difficult to identify the active peptide

Approach 2 – Targeted Design (Top-down)

Identify a physiological target

↓

Identify the receptor or pathway

↓

Design or search for peptides predicted to interact with it

↓

Test and optimise

Approach 2 – Targeted Design (Top-down)

Advantages

- More focused
- Higher probability of success

Limitations

- Requires detailed biological knowledge
- Biology is often more complex than expected

Table 1. Published works on bioactive peptides extracted from different natural resources.

Activity	Sequence	Mechanism	Study Model	Source	Reference
Antioxidant	YFMVLVVMLFHR	Free radical scavenging	*In vitro*	*Hermetiaillucens*	[125]
Antioxidant	APPPLQHQ	Free radical scavenging	*In vitro*	*Izmir Tulum cheeses*	[126]
Antioxidant	LEQQVDDLEGSLEQEKK	Free radical scavenging	*In vitro, in silico*	*Hams*	[127]
Antioxidant	GKHQQEEENEGGSI, VNPESQQGSPR, IGINAENNQRN, FVDAQPQQKEEG.	Free radical scavenging	*In vitro*	*Soymilk*	[128]
Antioxidant	AKCAKFQRNMKKVRG-NH2	Free radical scavenging	*In vitro*	*Milk proteins*	[129]
Antioxidant	IVVE	-	*In vitro*	*Chlorella (Chlorellavulgaris)*	[130]
Antioxidant	YWDAW	ROS Scavenging	*In vitro, in vivo* (Rat)	*Fish*	[131]
Antioxidant	MVVACVLPEA	Free radical scavenging	*In vitro*	*saltedjellyfish (Rhopilema hispidum)*	[132]
Antioxidant	EMPFPK, PYPQ, PQSV, YFYPE	Free radical scavenging	*In silico*	*Milk*	[133]
Antioxidant	VDPP, SSGE, DGEA, NQDK, WTP	Free radical scavenging	*In vitro*	*Salmo salar*	[134]
Antioxidant	LLGDV, NLDSS	Free radical scavenging	*In vitro*	*Rice wine*	[135]
Antioxidant	LPFR, WGFKPK, PFDLR, FPGEL	Free radical scavenging, tyrosinase inhibitory	*In vitro, in silico*	*Camelliaoleifera*	[136]
Antioxidant	FWENHDPTQGMR, SPFEKPGAPGKPTTT, AVGISKPSMPSKPF, SPFEKPGAPGKPTITA, STGISVPGPMGPSGPR, PEEERPKPSRPVVPPLIPPK, HPSDFGADAQAAMSK	Free radical scavenging	*In vitro*	*Freshbeef tripe*	[137]
Antihypertensive	IAE	ACE-inhibitory	*In vitro*	*Spirulina (Arthrospira platensis)*	[130]
Antihypertensive	YPDLPYH	ACE Inhibitory	*In vitro*	*YellowSilkCocoons*	[138]
Antihypertensive	VPP, IPP	ACE inhibitory	*In silico*	*Fermented sour milk*	[133]

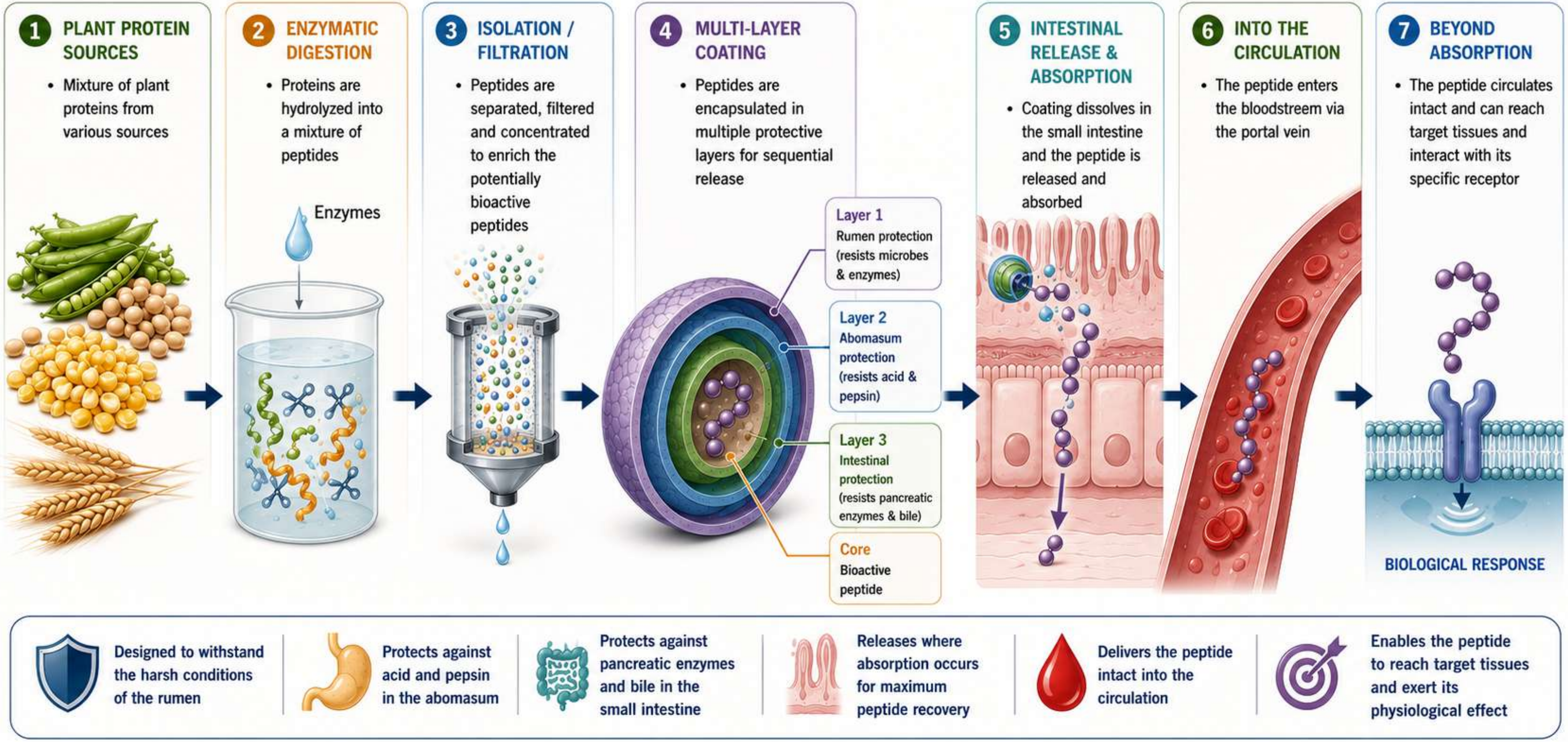
Summary of Bioactive Peptides (Adapted from Table 1)

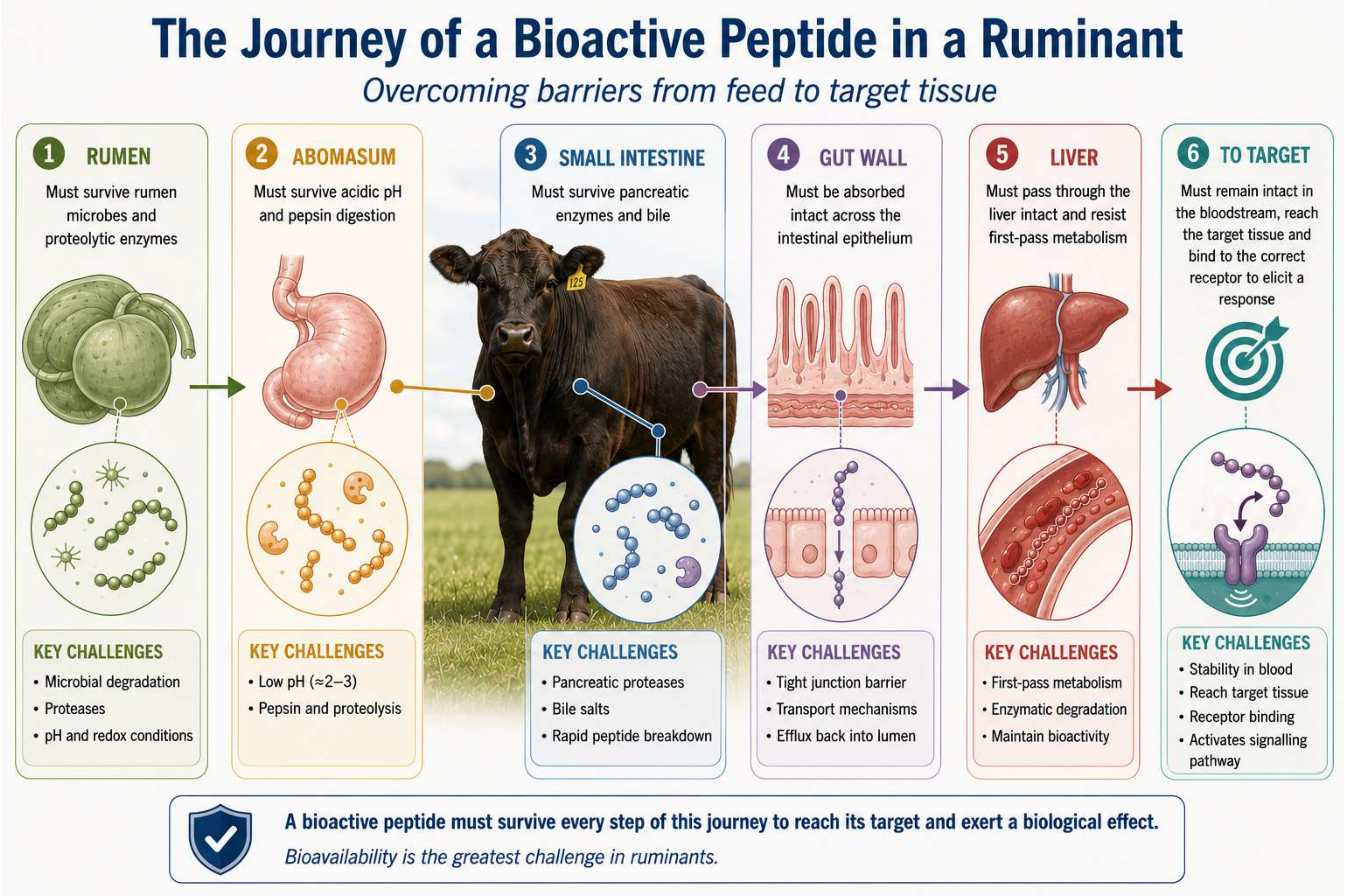
Rodríguez-Cabello et al. (2026)

Biological activity	Main mechanism	Typical study model	Examples of natural sources
Antioxidant	Free-radical (ROS) scavenging	In vitro, in silico, rodents	Common: Milk; Fish; Soy; Cereal grains; Spirulina; Salmo salar; Microalgae Interesting: Salted jellyfish; Yellow silk cocoons; Cicada chrysalis; Fresh beef tripe; Rice wine; Snake venom; Fly larvae; Frogs; Turkish cheese
Antihypertensive	ACE inhibition	In vitro, in silico, rodents	
Antithrombotic	Inhibition of platelet aggregation	In vitro, rodents	
Antimicrobial	Inhibition of bacterial growth	In vitro, in silico	
Antidiabetic	DPP-IV inhibition; α-glucosidase inhibition	In vitro, in silico	
Anticancer	Cancer cell elimination / growth inhibition	In vitro	
Osteoprotective	Suppression of inflammation	In silico	

From Plant Proteins to Bioactive Peptide in the Circulation

The journey of a bioactive peptide




The Journey of a Bioactive Peptide in a Ruminant
Overcoming barriers from feed to target tissue
1 RUMEN
Must survive rumen microbes and proteolytic enzymes
KEY CHALLENGES
• Microbial degradation
• Proteases
• pH and redox conditions
2 ABOMASUM
Must survive acidic pH and pepsin digestion
KEY CHALLENGES
• Low pH (≈2–3)
• Pepsin and proteolysis
3 SMALL INTESTINE
Must survive pancreatic enzymes and bile
KEY CHALLENGES
• Pancreatic proteases
• Bile salts
• Rapid peptide breakdown
4 GUT WALL
Must be absorbed intact across the intestinal epithelium
KEY CHALLENGES
• Tight junction barrier
• Transport mechanisms
• Efflux back into lumen
5 LIVER
Must pass through the liver intact and resist first-pass metabolism
KEY CHALLENGES
• First-pass metabolism
• Enzymatic degradation
• Maintain bioactivity
6 TO TARGET
Must remain intact in the bloodstream, reach the target tissue and bind to the correct receptor to elicit a response
KEY CHALLENGES
• Stability in blood
• Reach target tissue
• Receptor binding
• Activates signalling pathway
125
A bioactive peptide must survive every step of this journey to reach its target and exert a biological effect.
Bioavailability is the greatest challenge in ruminants.

There are really **three stages** in the BP story:

1. **Discovery**
   1. Which proteins contain interesting peptide sequences?
   2. Bioinformatics, databases, AI, and laboratory screening all play a role.
2. **Release**
   1. How do we liberate those peptides from the parent protein?
   2. This is where enzyme selection, pH, temperature, reaction time, etc., become critical. **Bioactive Peptide Engineering**
3. **Delivery**
   1. Once you have the peptide, how do you get it through the rumen, stomach, and intestine intact and absorbed into the bloodstream?
   2. This is where encapsulation and delivery technology become important.

Supporting data?!

- … "There is a paucity of empirical data regarding the use of bioactive peptides in feedlot and dairy cattle”
- Reasons:
  - BPs for ruminants is a rather novel field
  - The rumen is a challenging obstacle

    … not many peptides get through it intact
- Some data from Brazil
  - Demonstrative purposes, rather than supporting evidence

Feedlot pen trial

- 224 yearling Nelore cattle
- 16 pens; 14 animals per pen
- Feeding period: 101 days
- Treatments:
  - Control
  - 1 gram BP product per kg feed DM
  - 2 grams BP product per kg feed DM
  - 3 grams BP product per kg feed DM

Feedlot pen trial

Variable	Treatment (g BP product/kg feed DM)				Ctrl vs Trt
	Control	1	2	3	
Initial BW (kg)	376	377	376	377	
Feed intake (kg/d)	11.1	11.4	11.0	11.3	0.56
ADG (kg)	1.710	1.850	1.790	1.820	0.03
FE (gain: feed)	0.157	0.165	0.170	0.160	0.26
Cold carcass weight (kg)	300	309	307	304	0.03

ADG: 140 grams ↑
Cold carcass weight: 9 kg
↑

Feedlot individual-pen trial

- 40 yearling Nelore cattle
- Individual pens
- Feeding period: 79 days
- Treatments:
    - Control
    - 1 gram BP product per kg feed DM

Feedlot individual pen trial

Variable	Control	BP product	P-value
Initial BW (kg)	435	432	0.656
Feed intake (kg/d)	9.00	9.76	0.086
ADG (kg)	1.49	1.62	0.251
Dressing %	56.3	57.0	0.188
Cold carcass weight (kg)	311.3	320.8	0.071

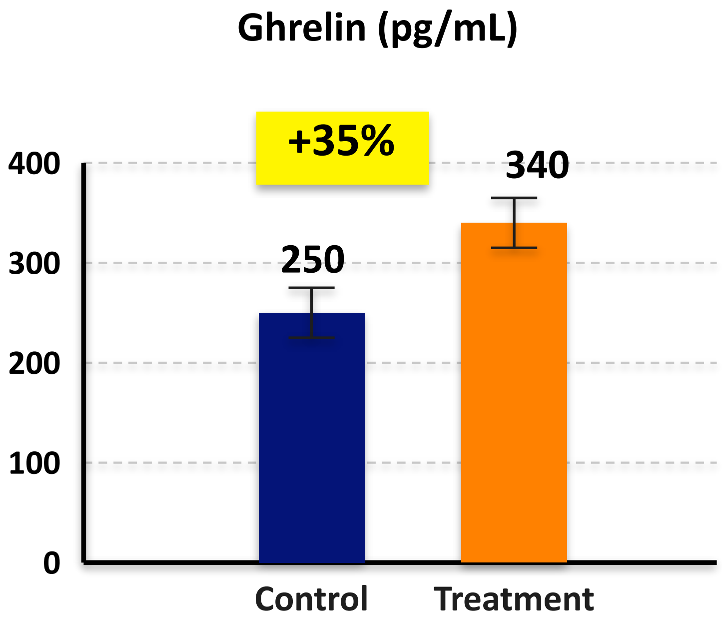
Cold carcass weight: 9.5 kg ↑

Dairy cow trial 1 (Correia *et al,* 2024)

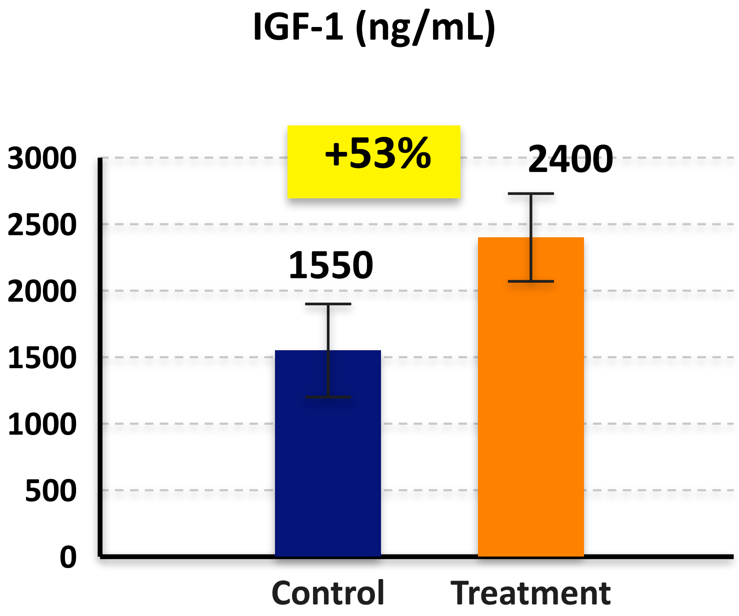
Federal University of Pelotas (Brazil)
NUPEEC-HUB – Center for Research, Education and Extension in Livestock Production

- 37 Holstein cows
- 36 months of age (avg)
- Primiparous
- 60 to 150 DIM
- 1 g BP product per kg of TMR DM *vs* Control (no BP product)
- Fed ad lib; daily DMI *ca* 23 kg
- Milked twice daily
- Blood samples collected on Days 0, 7, 14, 21, 28, 35, 42, 60, 75, and 90

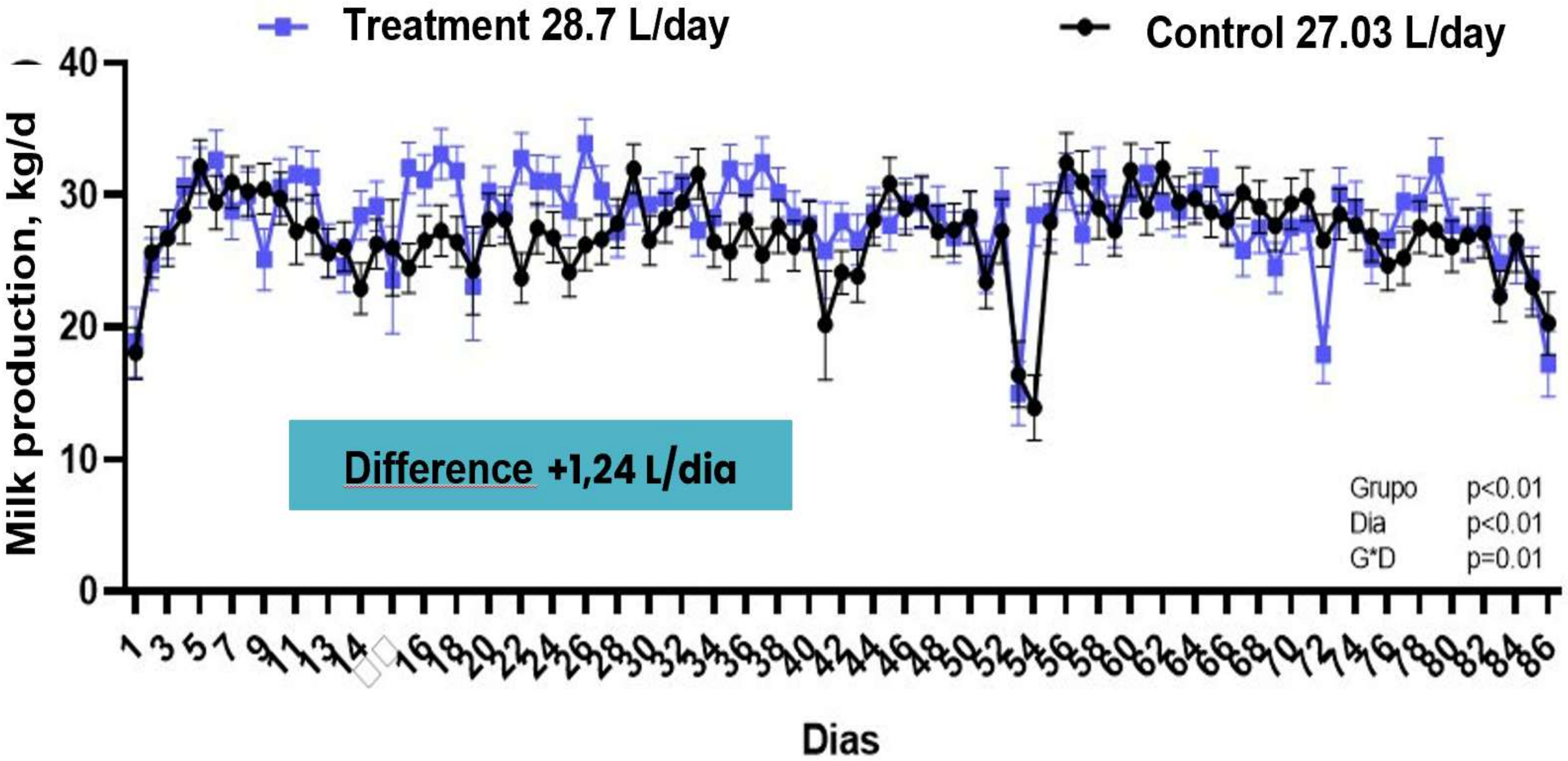
BP product increased ***ghrelin*** production and tended to increase ***IGF-1*** levels



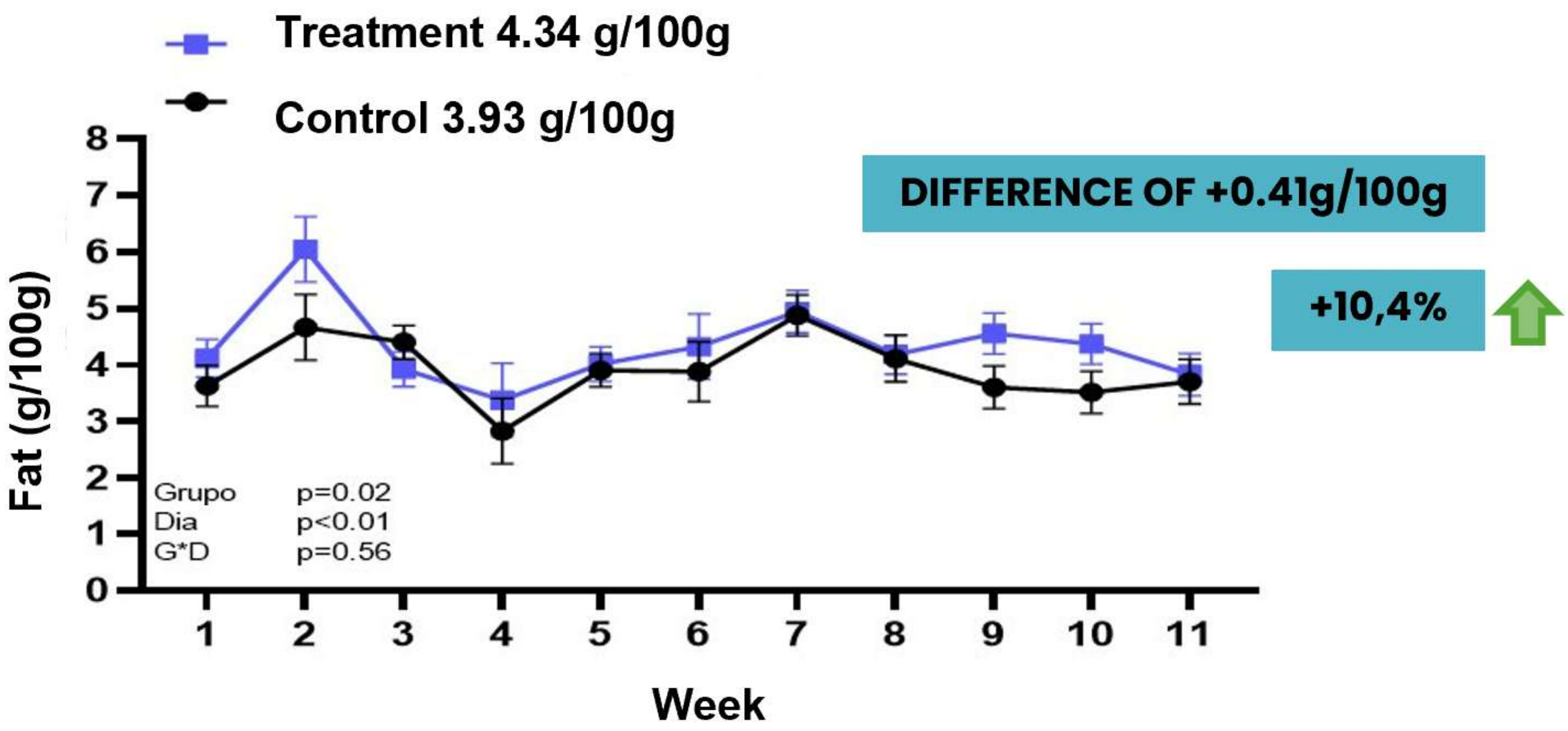
Group p<0.01
Day p=0.06
G×D p<0.01



Group p=0.08
Day p=0.25
G×D p=0.56



Treatment 28.7 L/day
Control 27.03 L/day
Milk production, kg/d
Difference +1,24 L/dia
Grupo p<0.01
Dia p<0.01
G*D p=0.01
Dias



Treatment 4.34 g/100g
Control 3.93 g/100g
DIFFERENCE OF +0.41g/100g
+10,4%
Fat (g/100g)
8
7
6
5
4
3
2
1
0
Grupo p=0.02
Dia p<0.01
G*D p=0.56
1 2 3 4 5 6 7 8 9 10 11
Week

Dairy cow trial 2 (Nehme Marinho *et al,* 2024)

University of Florida

- 18 Holstein cows
- 3 x 3 Latin square; 28d experimental periods
- Multiparous
- From 68 DIM
- 0, 1, or 2 g BP product per kg of TMR DM
- Milked thrice daily

+2,1 kg

+4,41%

+130g

+8,66%

Table. Effect of supplemental bioactive peptides on performance of Holstein cows

	Treatment				P-value	
Item	T0	T1	T2	SEM	Linear	Quadratic
DMI, kg/d	26.8	26.7	26.8	0.6	0.96	0.85
Milk, kg/d	52.3	52.8	52.5	0.9	0.70	0.21
ECM, kg/d	47.6	49.7	49.6	1.0	0.02	0.09
ECM/DMI, kg/kg	1.80	1.89	1.86	0.06	0.32	0.25
Fat, %	2.91	3.07	3.13	0.14	0.01	0.41
Fat, kg/d	1.50	1.63	1.63	0.06	0.01	0.12
Fatty acids, kg/d						
< 16 C	0.38	0.41	0.41	0.02	0.01	0.10
16 C	0.51	0.56	0.56	0.02	0.02	0.09
> 16 C	0.46	0.50	0.51	0.02	0.004	0.19
Protein, %	2.77	2.80	2.80	0.04	0.20	0.37
Protein, kg/d	1.45	1.48	1.47	0.04	0.14	0.08

Dairy cow, bioactive peptides, production

Concluding remarks

- For humans, BPs have arrived – it is the new bandwagon
- For ruminants?
  - Makes sense; holds promise
  - Faces challenges
  - *(Will BPs make it to the feedlot and the dairy?)* ***cost : benefit ?***
- With the rapid growth in technology (including AI), expect to see bioactive peptides in the feed technology toolbox sooner rather than later ***keep a lookout for it …***
- **Bioactive Peptides** may well be the next ***champion***!

THANK YOU!