Enzymes – use in Food production

EIT Food course

On-line, 12th of October 2022

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Research scientist

Matís activities

Research and innovation projects

Analytical services

Public safety and priority services

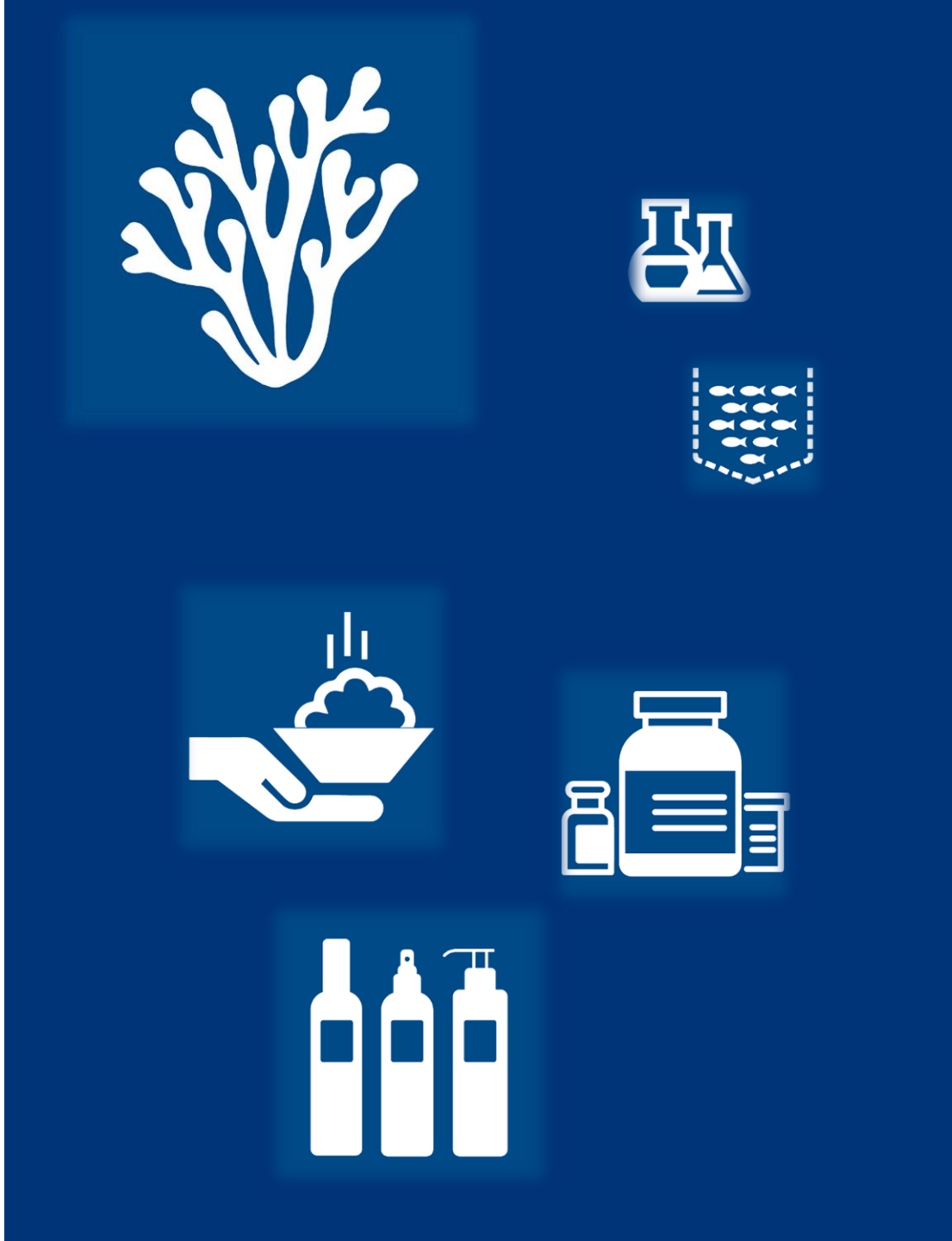
National reference laboratories

Consulting, education, facilities

Impact of our research –> matis.is

Enzymes - definition

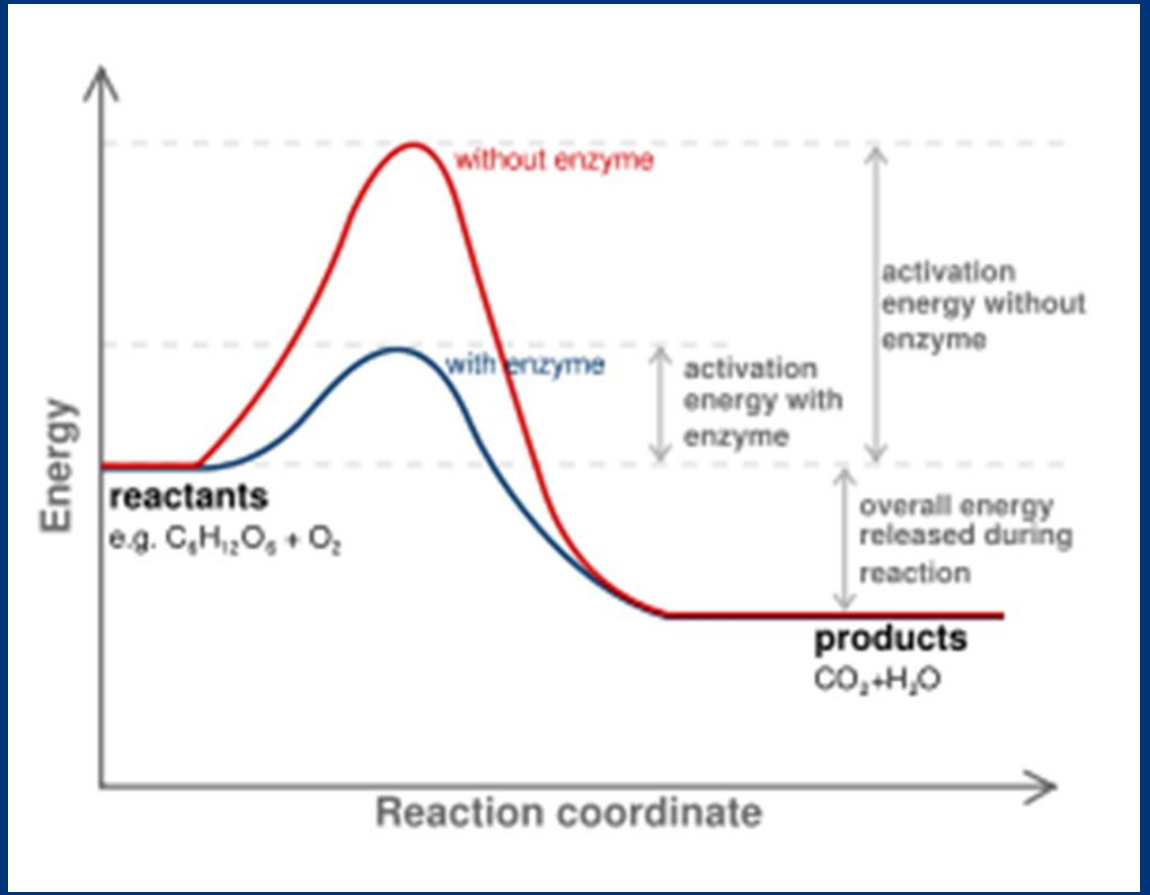
- Enzymes are **proteins** that increase the rate of reaction by lowering the energy of activation
- They **catalyse** nearly all the chemical reactions taking place in the cells of the body
- Not altered or consumed during reaction
- Reusable



Activation energy

- Like all catalysts, enzymes work by lowering the activation energy (Ea or ΔG‡) for a reaction, thus dramatically accelerating the rate of the reaction.

- Most enzyme reaction rates are **millions** of times faster than those of comparable uncatalyzed reactions.



Enzymatic reaction

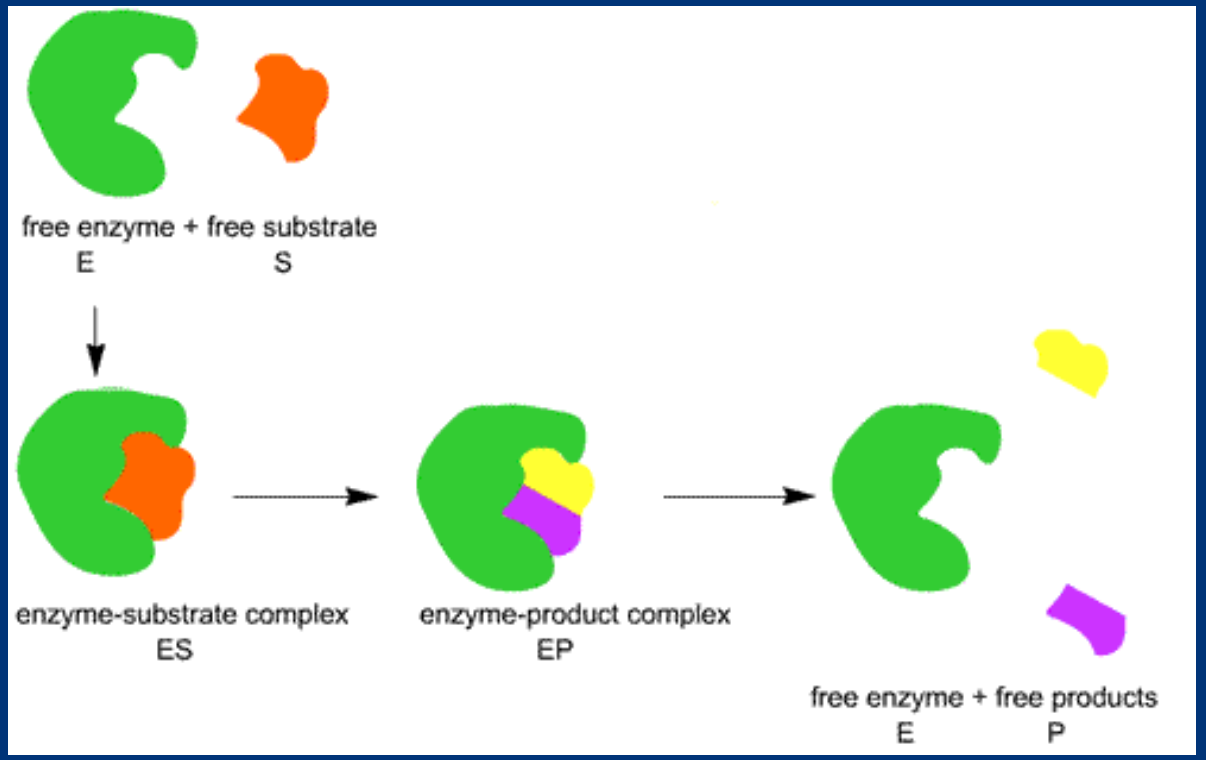
- **Enzymes**

✓ Proteins that accelerate chemical reactions [E]

- **Molecules called**

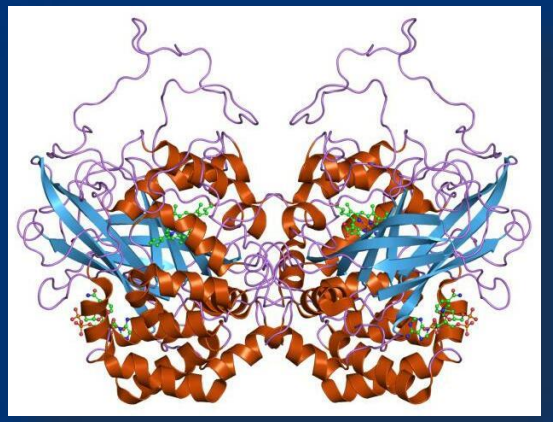
✓ Substrates [S]

✓ Products [P]

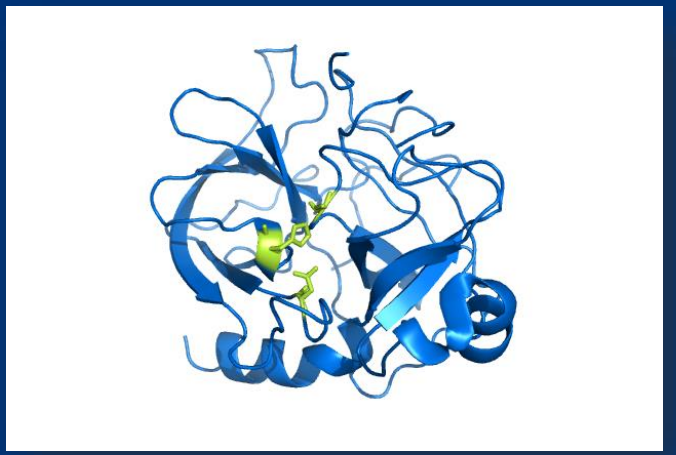


Enzymes - classes

- Oxidoreductases
- Transferases
- Hydrolases
- Lyases
- Isomerases
- Ligases



Catalase (Oxireductase)



Serine protease

Pictures from Wikipedia

Types of enzymes used in food production

Class	Enzyme	Role
Oxidoreductases	Glucose oxidase Laccases Lipoxygenase	Dough Clarification of juices, flavour enhancer (beer) Dough strengthening, bread whitening
Transferases	Cyclodextrin Fructosyltransferase Transglutaminase	Cyclodextrin production Synthesis of fructose oligomers Modification of viscoelastic properties, dough processing, meat processing
Lyases	Acetolactate decarboxylase	Beer maturation
Isomerases	Xylose (Glucose) isomerase	Glucose isomerization to fructose
Hydrolases	….. Next slide	

From: Fernandes 2010. https://doi.org/10.4061%2F2010%2F862537

Hydrolases have many roles in food production (1/2)

Enzyme	Role
Amylases	Starch liquefaction and sachcarification
	Increasing shelf life and improving quality by retaining moist, elastic and soft nature
	Bread softness and volume, flour adjustment, ensuring uniform yeast fermentation
	Juice treatment, low calorie beer
Galactosidase	Viscosity reduction in lupins and grain legumes used in animal feed, enhanced digestibility
Glucanase	Viscosity reduction in barley and oats used in animal feed, enhanced digestibility
Glucoamylase	Saccharification
Invertase	Sucrose hydrolysis, production of invert sugar syrup
Lactase	Lactose hydrolysis, whey hydrolysis
Lipase	Cheese flavour, in-situ emulsification for dough conditioning, support for lipid digestion in young animals, synthesis of aromatic molecules

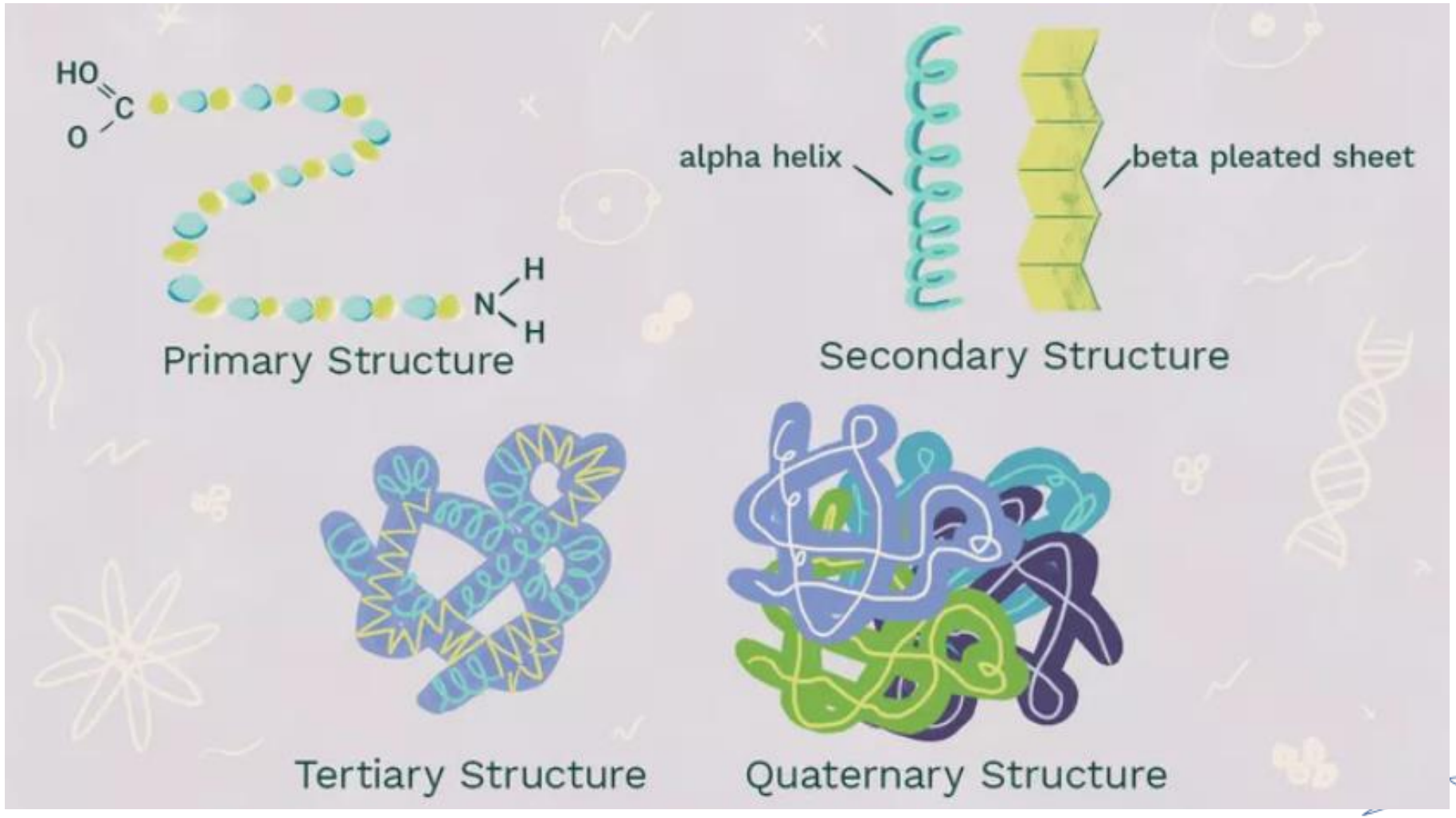
From: Fernandes 2010. https://doi.org/10.4061%2F2010%2F862537

Hydrolases have many roles in food production (2/2)

Enzyme	Role
Amylases	Starch liquefaction and sachcarification
Proteases	Protein hydrolysis, milk clotting, low-allergenic infant-food formulation, enhanced digestibility and utilization, flavour improvement in milk and cheese, meat tenderizer, prevention of chill haze formation in brewing
Pectinase	Mash treatment, juice clarification
Peptidase	Hydrolysis of proteins (namely, soy, gluten) for savoury flavours, cheese ripening
Phospholipase	In-situ emulsification for dough conditioning
Phytases	Release of phosphate from phytate, enhanced digestibility
Pullulanase	Saccharification
Xylanases	Viscosity reduction, enhanced digestibility, dough conditioning

From: Fernandes 2010. https://doi.org/10.4061%2F2010%2F86

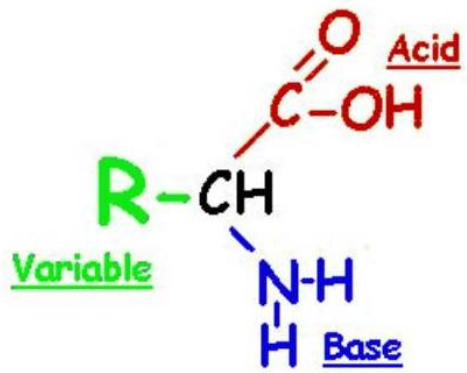
Types of protein structures



https://www.thoughtco.com/protein-structure-373563

Amino-acids

Proteins are made from amino acids



A theoretical amino acid

A GUIDE TO THE TWENTY COMMON AMINO ACIDS

AMINO ACIDS ARE THE BUILDING BLOCKS OF PROTEINS IN LIVING ORGANISMS. THERE ARE OVER 500 AMINO ACIDS FOUND IN NATURE - HOWEVER, THE HUMAN GENETIC CODE ONLY DIRECTLY ENCODES 20. 'ESSENTIAL' AMINO ACIDS MUST BE OBTAINED FROM THE DIET, WHILST NON-ESSENTIAL AMINO ACIDS CAN BE SYNTHESISED IN THE BODY.

Chart Key: ALIPHATIC · AROMATIC · ACIDIC · BASIC · HYDROXYLIC · SULFUR-CONTAINING · AMIDIC · NON-ESSENTIAL · ESSENTIAL

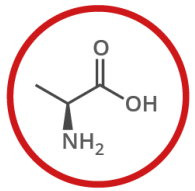
Chemical Structure

single letter code

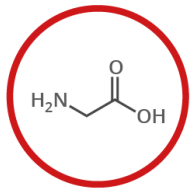
NAME A

three letter code

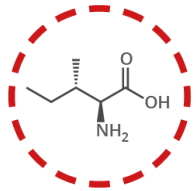
DNA codons



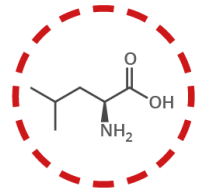
ALANINE A
Ala
GCT, GCC, GCA, GCG



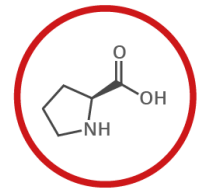
GLYCINE G
Gly
GGT, GGC, GGA, GGG



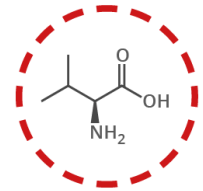
ISOLEUCINE I
Ile
ATT, ATC, ATA



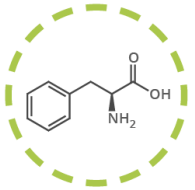
LEUCINE L
Leu
CTT, CTC, CTA, CTG, TTA, TTG



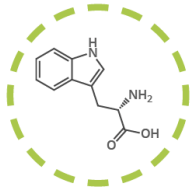
PROLINE P
Pro
CCT, CCC, CCA, CCG



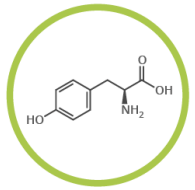
VALINE V
Val
GTT, GTC, GTA, GTG



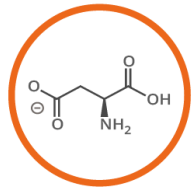
PHENYLALANINE F
Phe
TTT, TTC



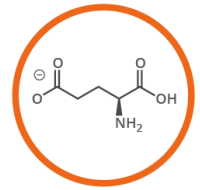
TRYPTOPHAN W
Trp
TGG



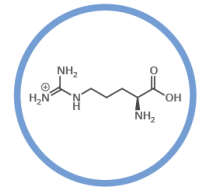
TYROSINE Y
Tyr
TAT, TAC



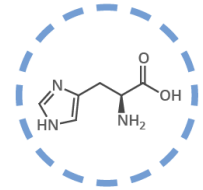
ASPARTIC ACID D
Asp
GAT, GAC



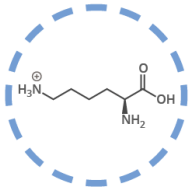
GLUTAMIC ACID E
Glu
GAA, GAG



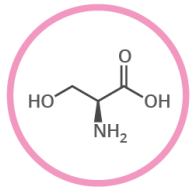
ARGININE R
Arg
CGT, CGC, CGA, CGG, AGA, AGG



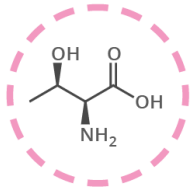
HISTIDINE H
His
CAT, CAC



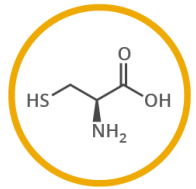
LYSINE K
Lys
AAA, AAG



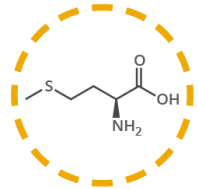
SERINE S
Ser
TCT, TCC, TCA, TCG, AGT, AGC



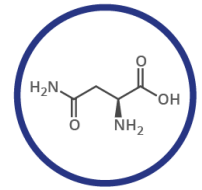
THREONINE T
Thr
ACT, ACC, ACA, ACG



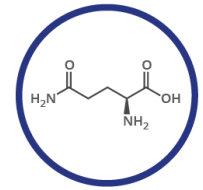
CYSTEINE C
Cys
TGT, TGC



METHIONINE M
Met
ATG



ASPARAGINE N
Asn
AAT, AAC

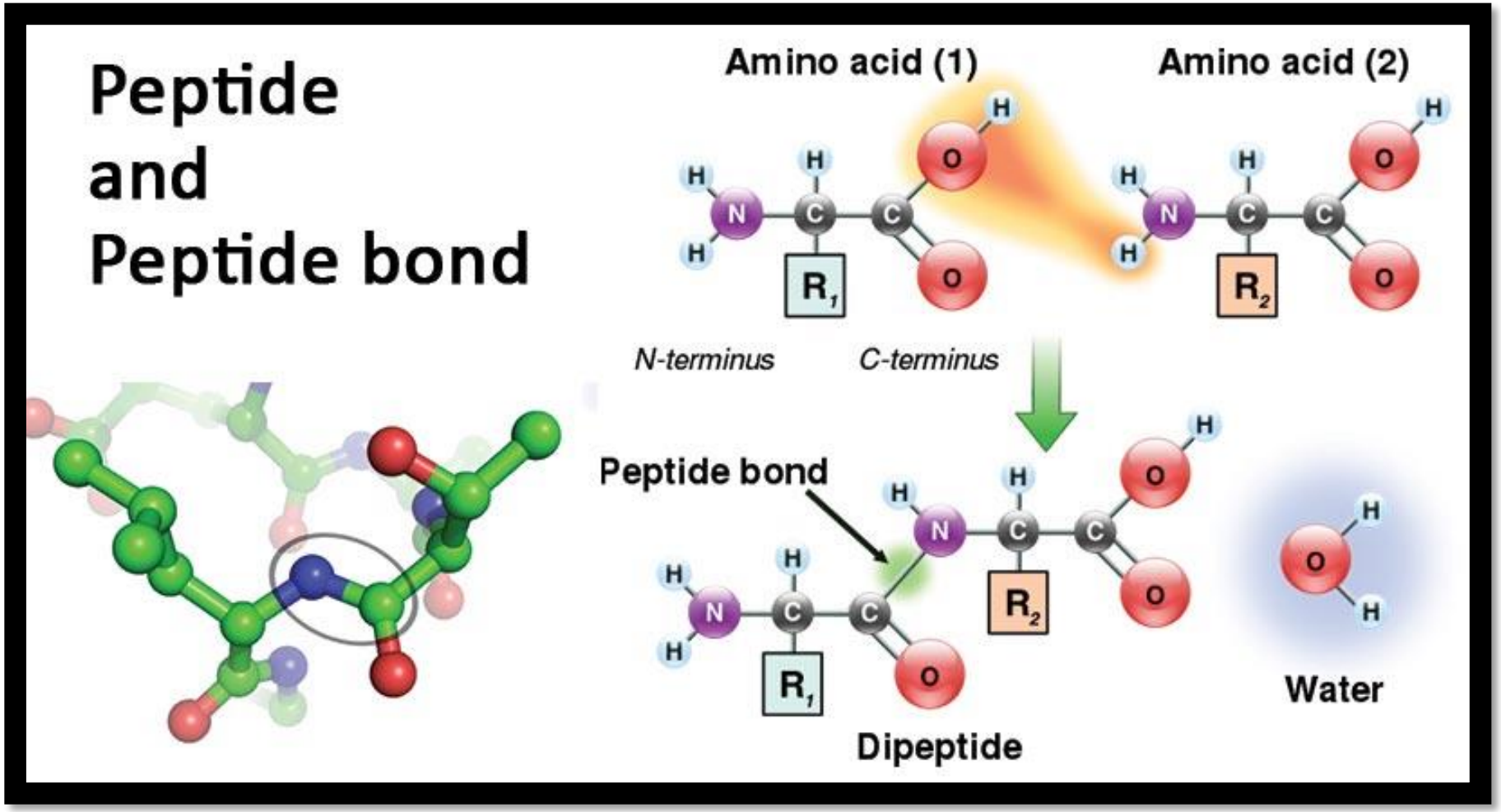


GLUTAMINE Q
Gln
CAA, CAG

Hildur I Sveinsdóttir / Margrét Geirsdóttir

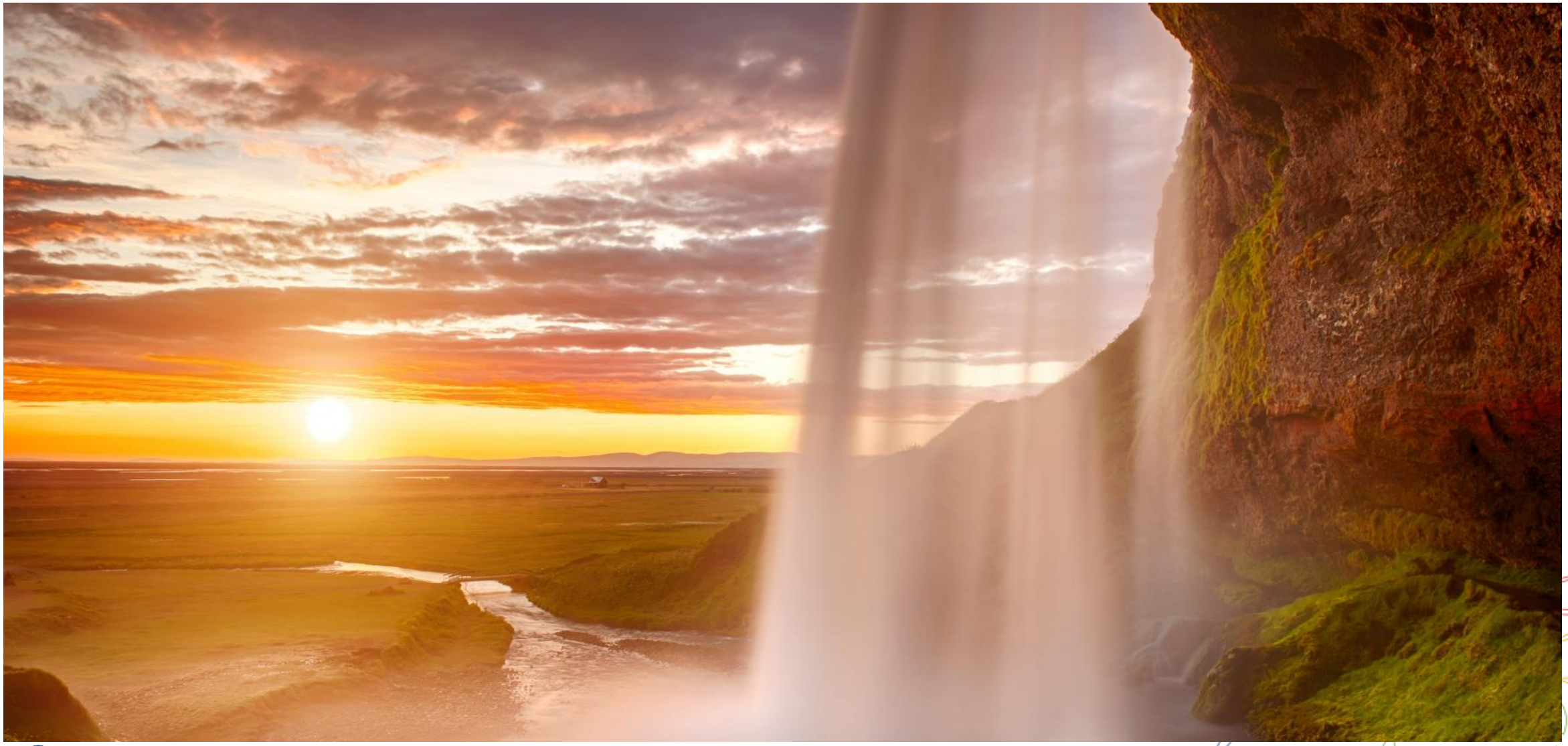
https://i0.wp.com/www.compoundchem.com/wp-content/uploads/2014/09/20-Common-Amino-Acids-v3.png?ssl=1

Amino-acids and peptide bond



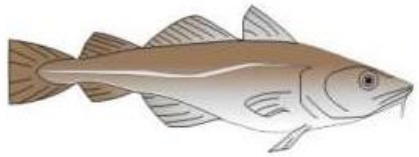
https://microbenotes.com/peptide-bond/

Cod – example of use of enzymes in food

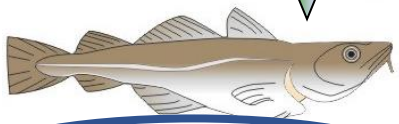


Production of cod fillet

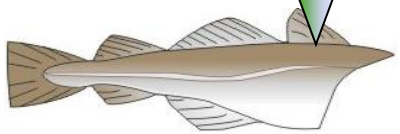
Side streams



Whole cod



Gutted cod 100 kg

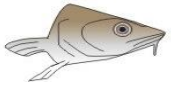


Headed cod 72 kg

Fillet skin- & boneless 49 kg

Belly flap 3 kg

Viscera 10 - 35 kg



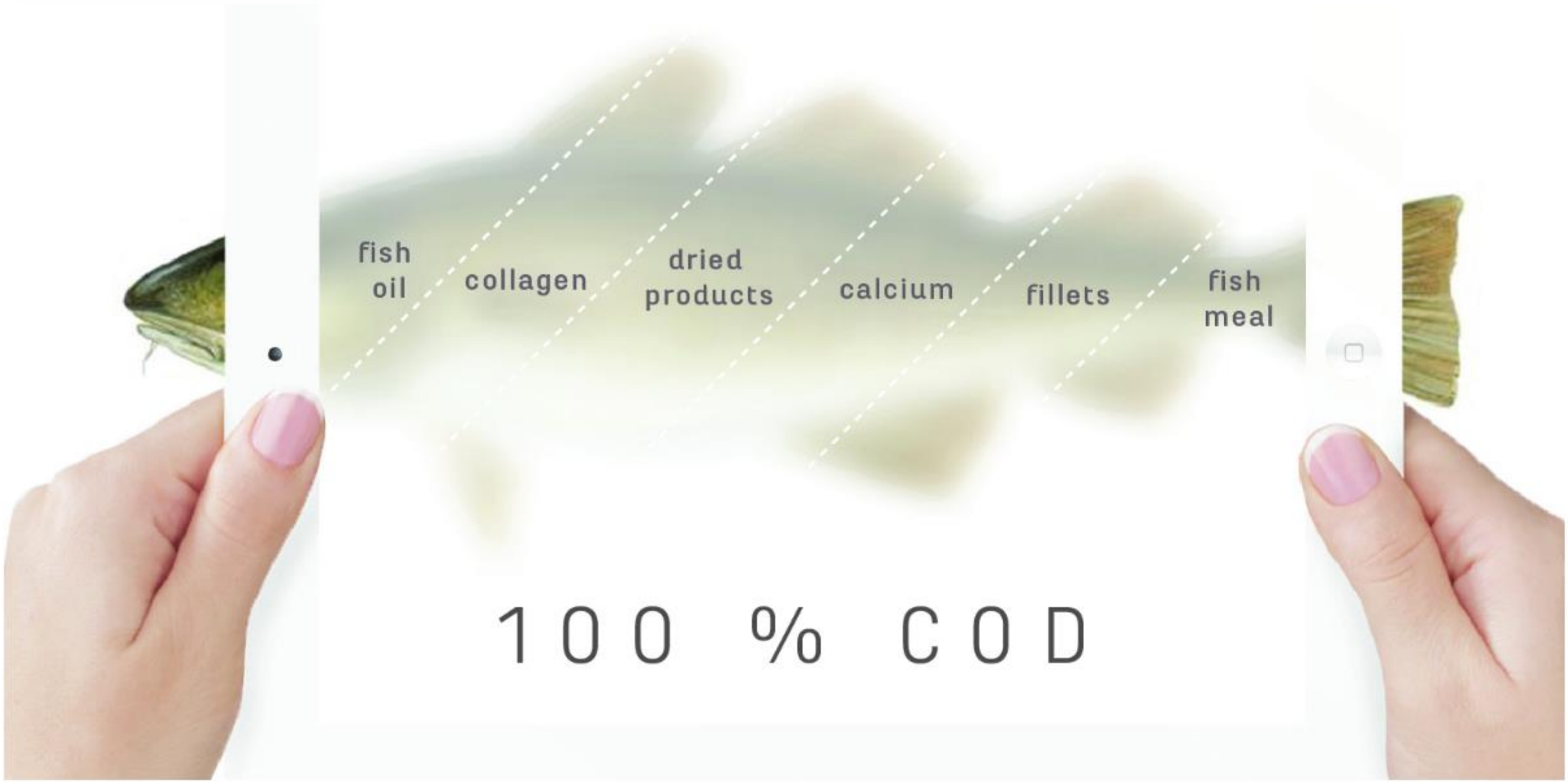
Head with collar 28 kg

Back bone 15 kg

Skin 3 kg

Cut-offs 4 kg

codland


fish oil
collagen
dried products
calcium
fillets
fish meal
100 % COD

Fish enzyme from the intestines

ZYMETECH

Fish skin

Cod skin, collagen and peptides

Enzymes - hydrolysis

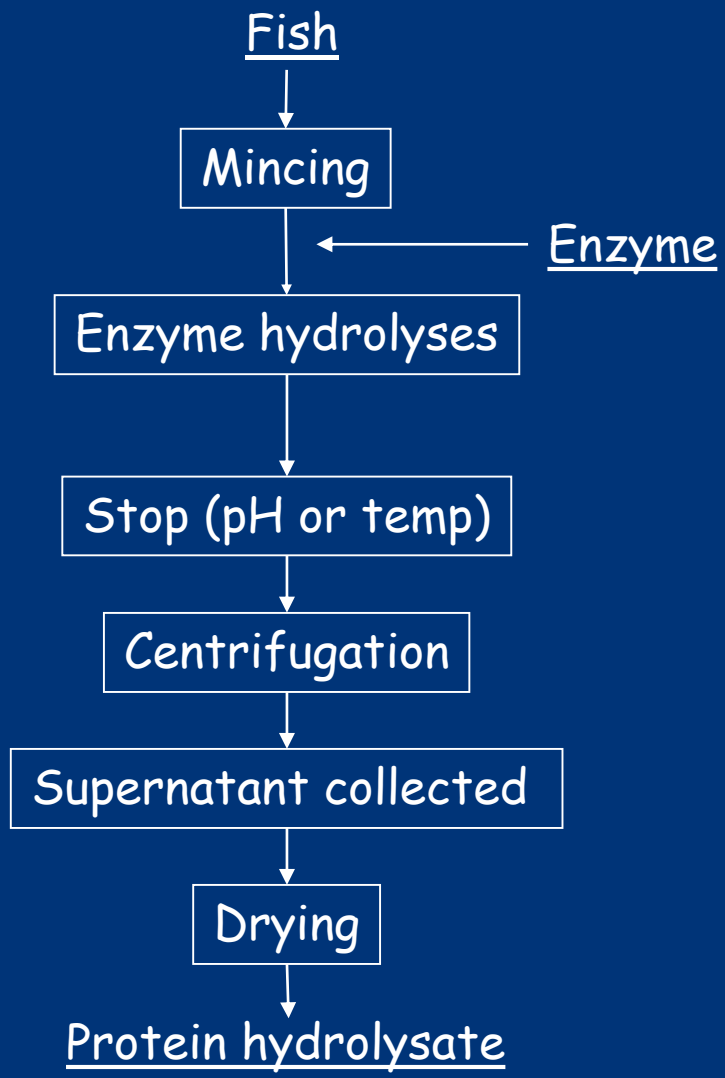
Pre-process?

Enzyme to use?

Conditions (pH, T, t, E/S)

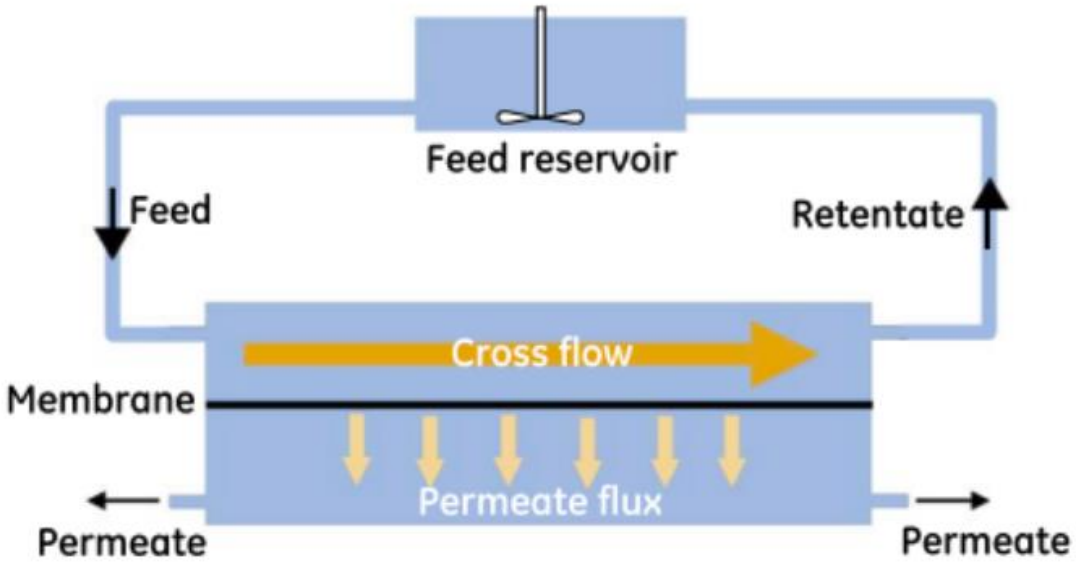
How to stop hydrolysis?

Post treatment?



Fractionation

- Tangential flow filtration
  - ✓ 30 kDa, 10 kDa and 5 kDa

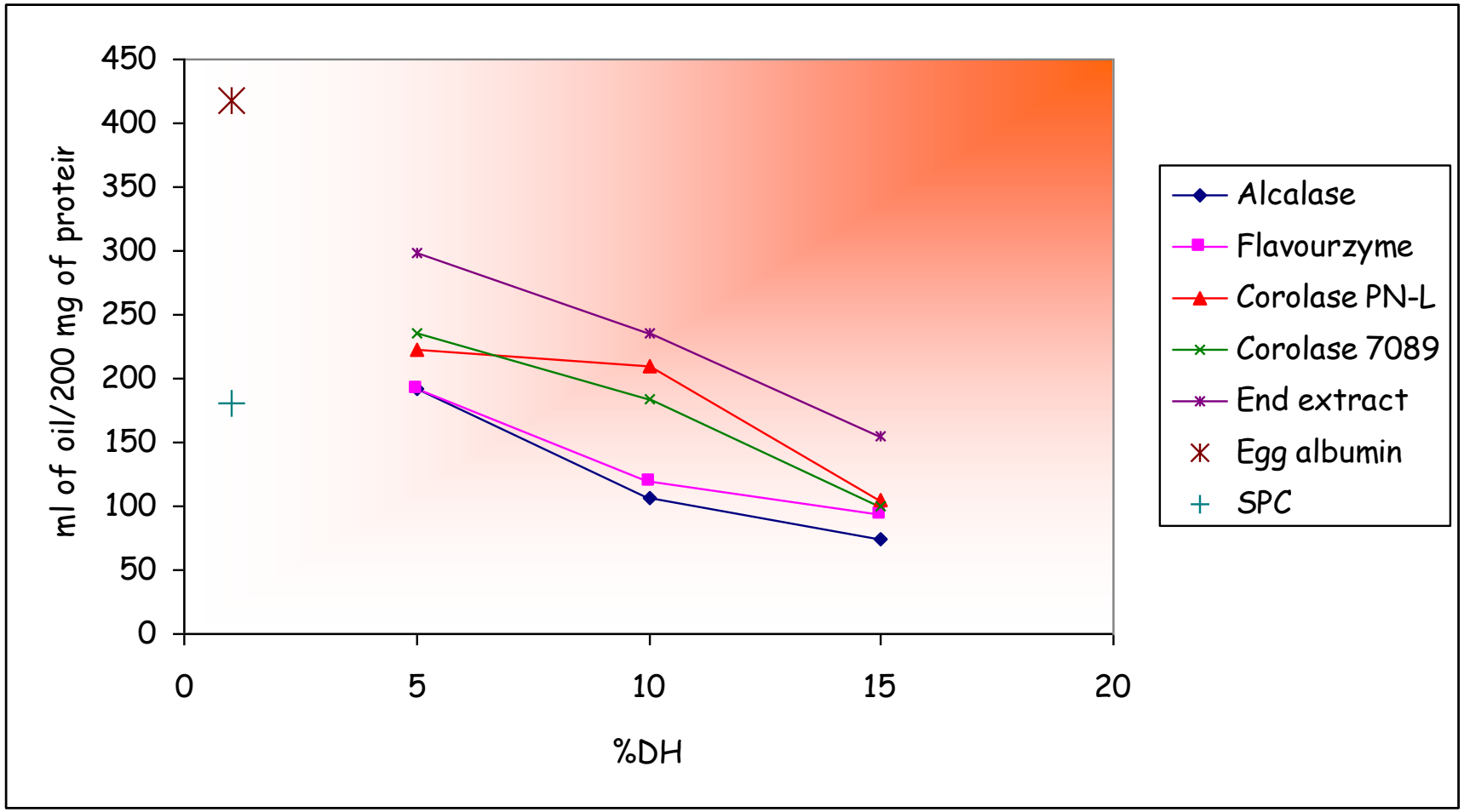


Bioactive properties

- Antioxidation
  - ✓ ORAC – Oxygen Radical Absorbance Capacity
  - ✓ MC – Metal Chelating
  - ✓ RP – Reducing Power

- Enzyme inhibition
  - ✓ Alpha amylase and alpha – glucosidase
  - ✓ ACE - Angiotensin Converting Enzyme
  - ✓ Elastase and collagenase

Emulsifying capacity



- Smaller peptides => less emulsifying capacity
- Salmon hydrolysate

Kristinsson and Rasco 2000

Examples of Icelandic products on the market with fish protein hydrolysates.

Protis – fish protein hydrolysates

Feel Iceland products

AGE REWIND SKIN THERAPY

AMINO MARINE COLLAGEN

AMINO MARINE COLLAGEN

JOINT REWIND - JOINT THERAPY

Thanks for you attention