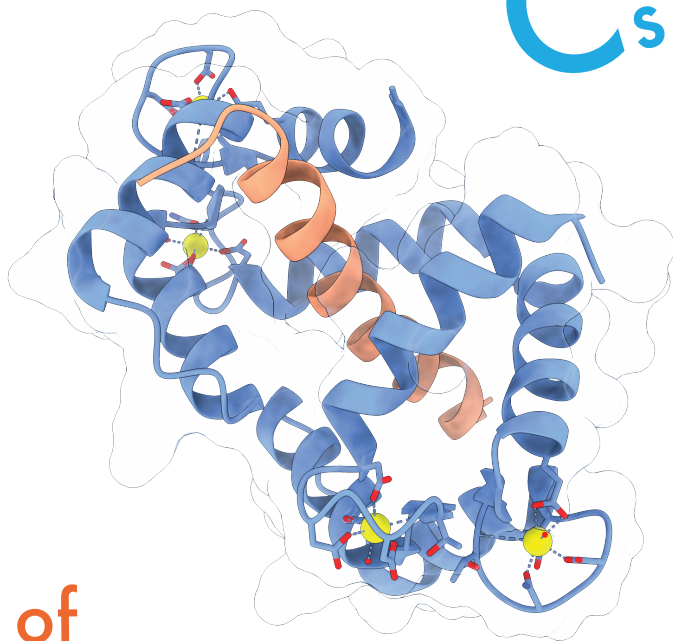


Dr. McShan's

A

B

C_s



of

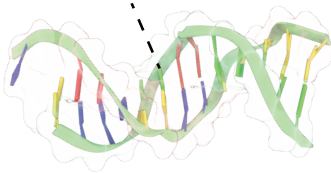
amazing

proteins!

PROTEINS are tiny machines that do fantastical things from humans to plants to snails they build the components of cells.

*** The architecture of proteins ***

DNA double helix

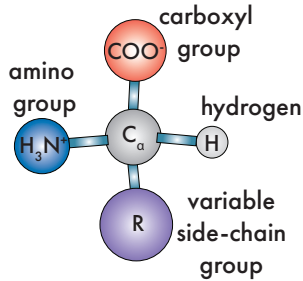


NUCLEIC ACIDS

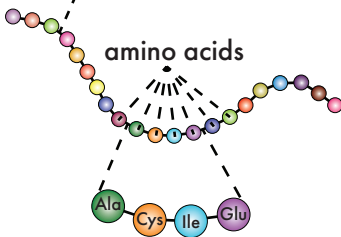
DNA and RNA. the "genetic code" that makes proteins

AMINO ACIDS

20 letter alphabet that makes up proteins



peptide bond (links amino acids)



PRIMARY STRUCTURE

sequence of amino acids

SECONDARY STRUCTURE

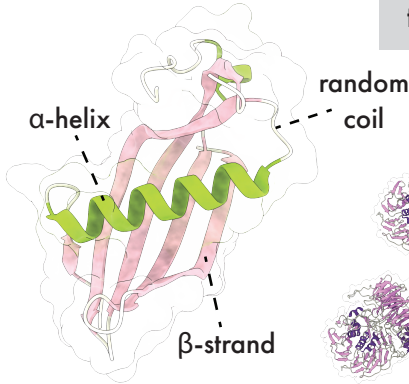
local structural elements

α -helix β -strand random coil



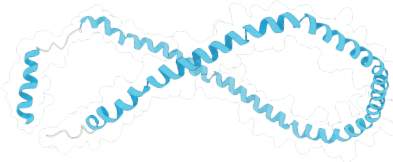
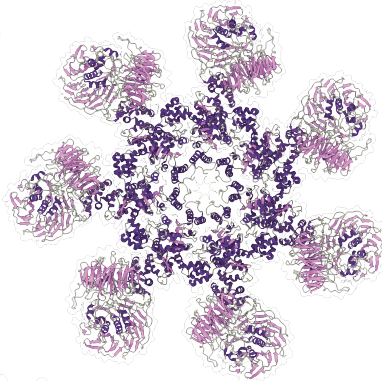
CYSTATIN C

marker of
kidney function



TERTIARY STRUCTURE

secondary structure
elements fold together
to make 3D structures



APOPTOSOME

regulates
cell death

APOLIPOPROTEIN A-I

cholesterol transport
and homeostasis

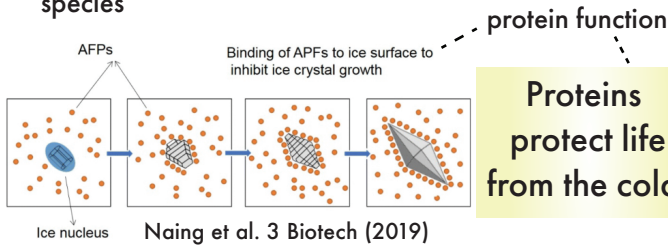
we can't see them with our eyes
they come in all shapes and all sizes.
read on and you'll get the gist
without proteins **LIFE** wouldn't exist!

protein
name

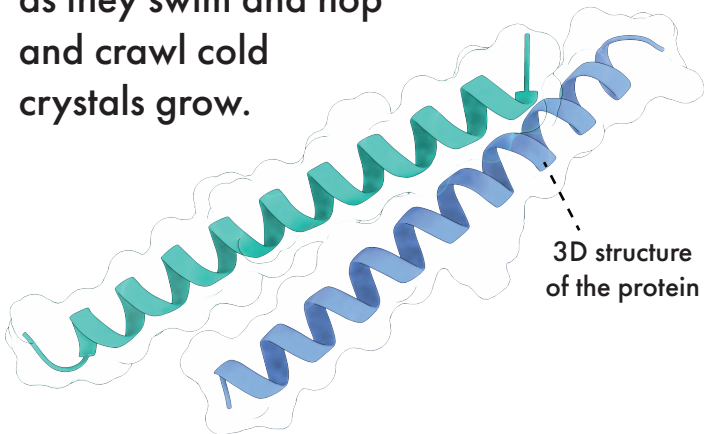
ANTIFREEZE

Pseudopleuronectes americanus

example
species (Winter flounder)



“brrr” go fish in seas,
frogs in ponds, and bugs in snow.
as they swim and hop
and crawl cold
crystals grow.

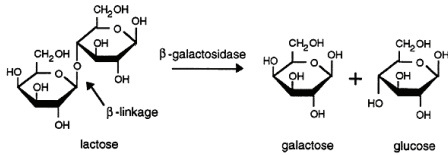


without **ANTIFREEZE**
they'd turn to ice,
but instead they survive
feeling perfectly nice.

BETA-GALACTOSIDASE

Escherichia coli
(Common bacteria)

Proteins help
digest sugars
in food/liquid!



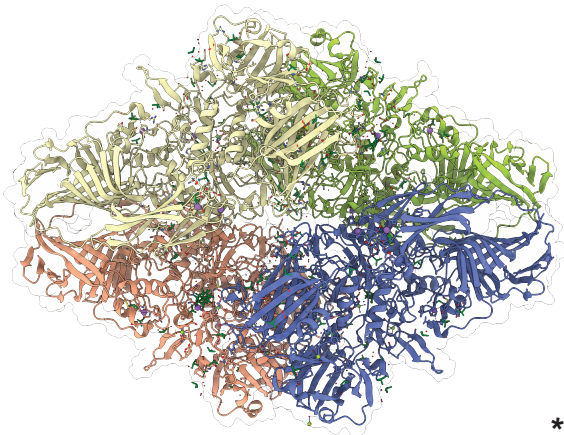
BETA-GALACTOSIDASE

is an enzyme with grace.

it generates energy

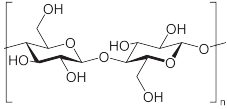
so you can run all over the place.

breaking down sugars with ease,
enzymes make digesting milk and
cookies a delicious breeze!

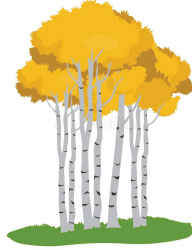


CELLULOSE SYNTHASE

Populus tremuloides
(Quaking aspen tree)



Cellulose
[makes up
plant cell walls]



Proteins help
plants grow
tall and strong!

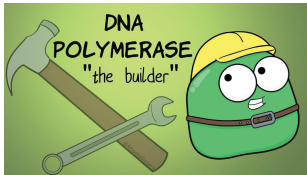
CELLULOSE SYNTHASE

weaves fibers
so tight, helping
stems and leaves
stand upright.
it stitches hundreds of
sugars molecules
together real
good to build
delicate flowers
and majestic
redwoods.



DNA POLYMERASE

Thermus aquaticus
(*thermophilic bacteria*)

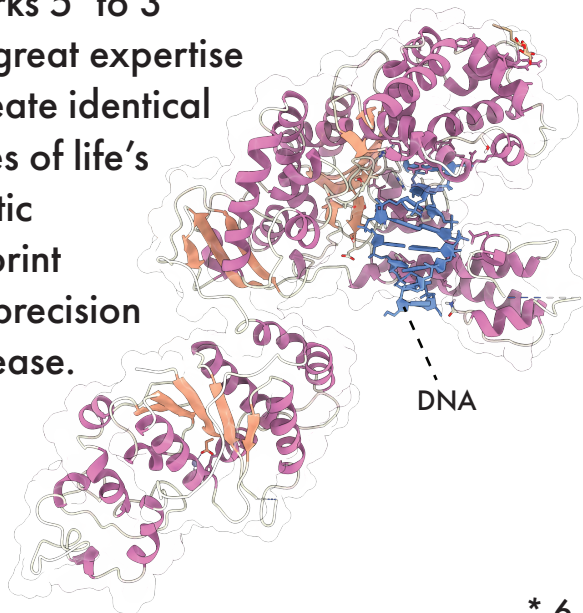


@AmoebaSisters

Proteins
make copies
of DNA!

DNA POLYMERASE

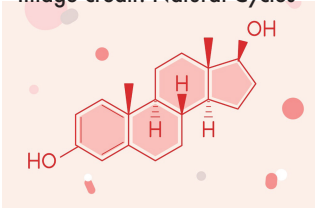
is quite the machine.
it works 5' to 3'
with great expertise
to create identical
copies of life's
genetic
blueprint
with precision
and ease.



ESTROGEN RECEPTOR

Homo sapiens (Humans)

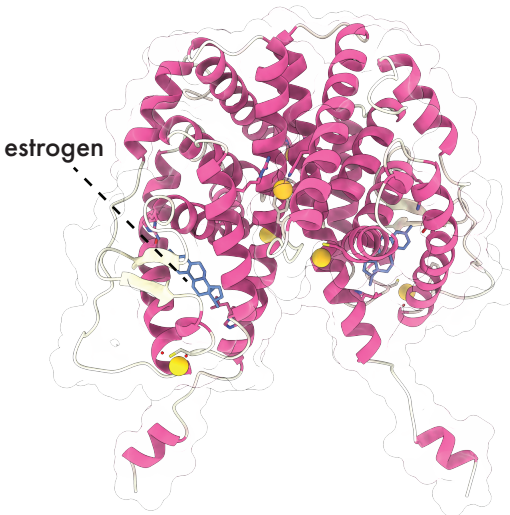
Image credit: Natural Cycles



Proteins help
your body
grow and change!

estrogen hormone

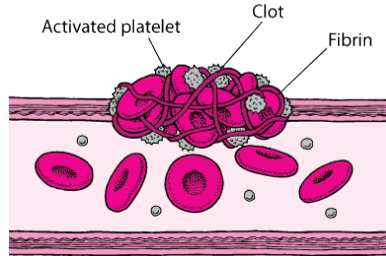
ESTROGEN RECEPTOR hangs out on the surface of all types of cells. when its hormone friend estrogen drops by to say "bonjour!" it helps the body grow and change more.



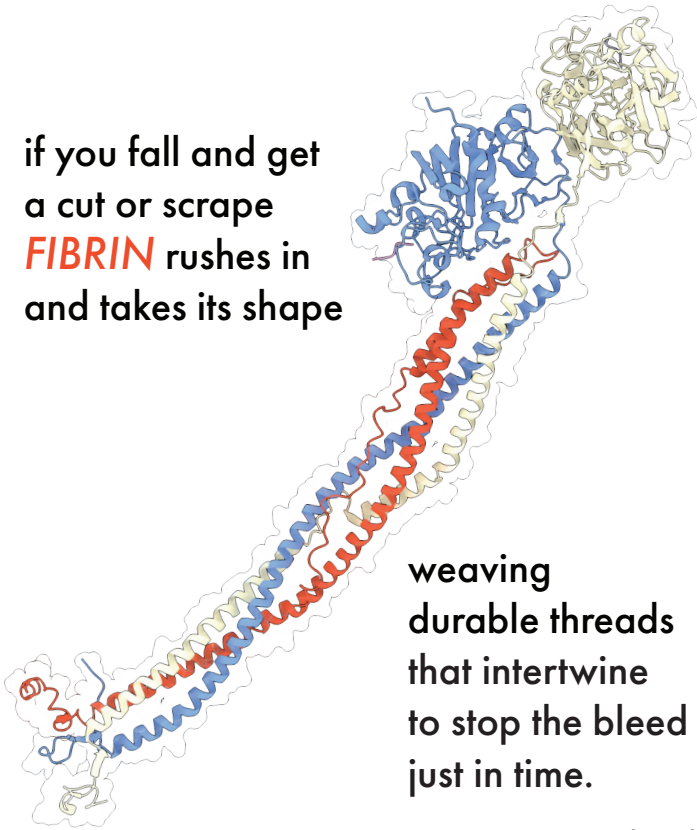
FIBRIN

Gallus gallus (Chicken)

Proteins help
stop you
from bleeding!



if you fall and get
a cut or scrape
FIBRIN rushes in
and takes its shape



weaving
durable threads
that intertwine
to stop the bleed
just in time.

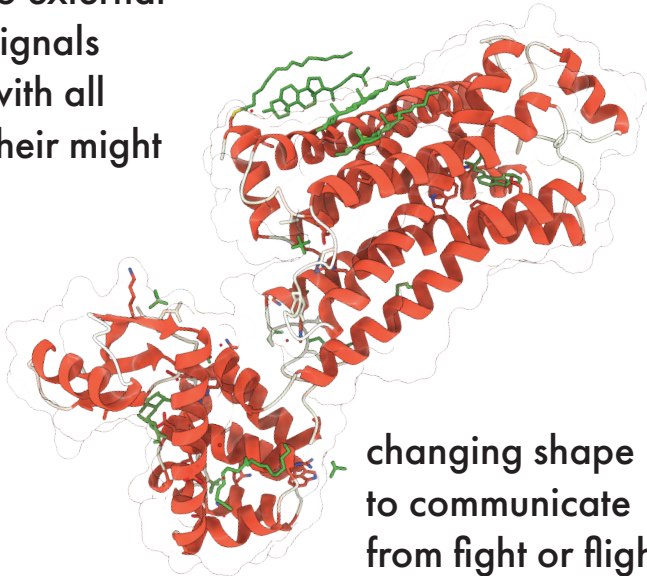
G PROTEIN- COUPLED RECEPTOR

Homo sapiens (Human)



Proteins help
you see, smell,
taste, and touch!

GPCRs respond
to external
signals
with all
their might

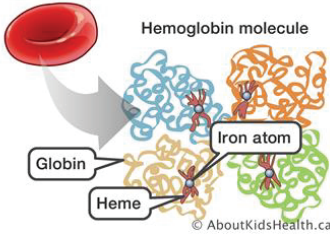


changing shape
to communicate
from fight or flight
to smell and sight

HEMOGLOBIN

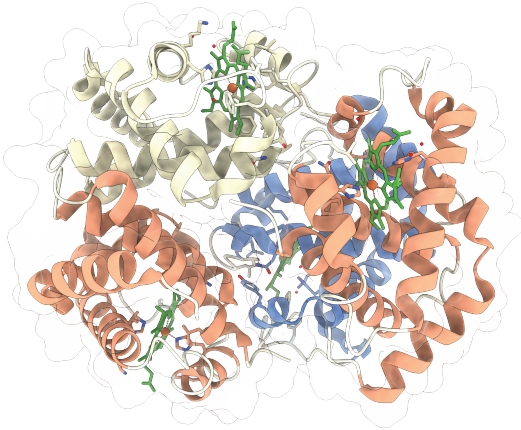
Homo sapiens (Human)

Red blood cell



Proteins
transport
oxygen
in blood!

in our blood lies a special team
comprised of **HEMOGLOBIN**
and oxygen to help you breathe



with iron and heme it carries O_2
through winding veins
from the lungs to tissues

INTERFERON

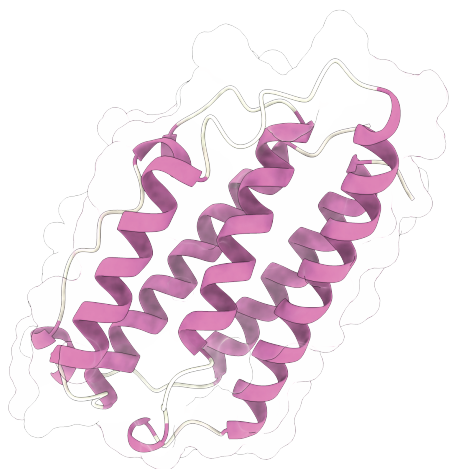
Homo sapiens (Human)

Proteins
protect you
from getting
sick!



Art: Leif Parsons

INTERFERON is a cytokine that serves as a cellular warning sign. when viruses or cancer attack its wisdom signals "go get 'em!" to the immune system.



JUN A1

Juniperus ashei
(Ashe juniper plant)



Art: KanKhem

Proteins
play roles
in allergy!

JUN A1 in pollen
carried by the summer breeze
make us sneeze and wheeze



KAI A

Synechococcus elongatus (Cyanobacteria)

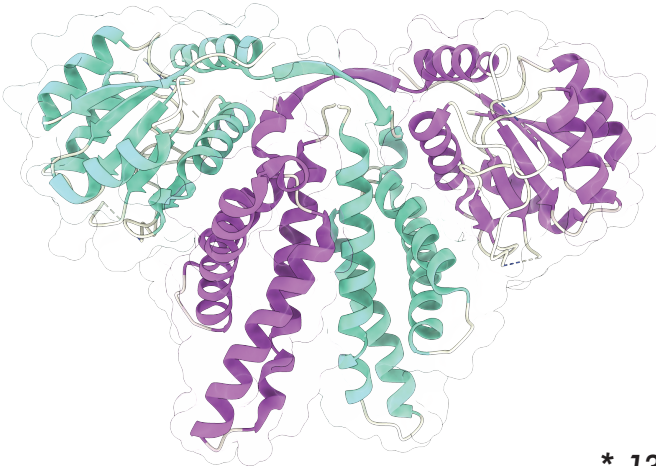
Art: elenabs



CIRCADIAN RHYTHM

Proteins
help keep
time!

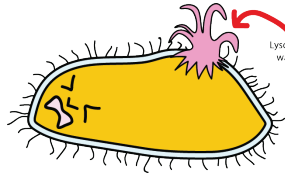
KAI A a protein with a special role,
keeps our circadian rhythm in control.
with its twenty-four-hour biological clock,
it regulates sleep and wake cycles
on the dot!



LYSOZYME

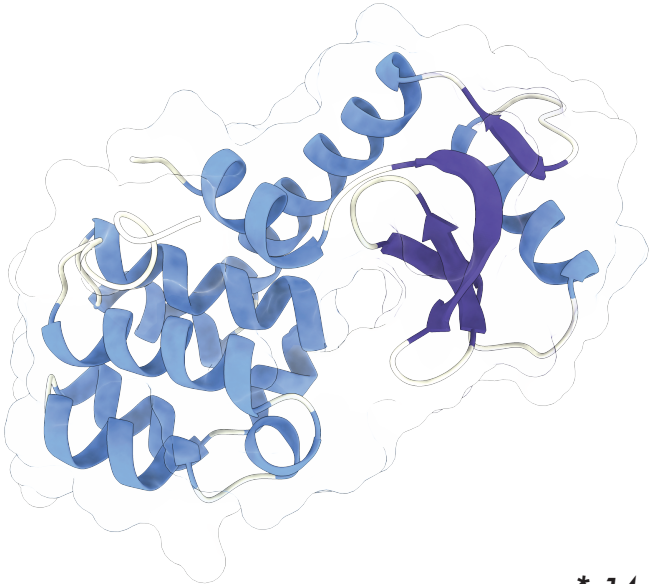
Escherichia virus T4

Proteins in tears
and saliva
protect you!



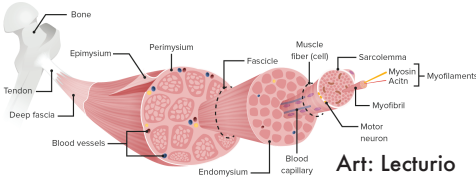
Lysozyme weakens the bacterial cell wall allowing it to rupture, killing the bacterium

in teardrops and saliva you'll find
a superhero enzyme, **LYSOZYME**.
it kills bacteria by lysing their cell wall
protecting you from germs big and small.



MYOSIN

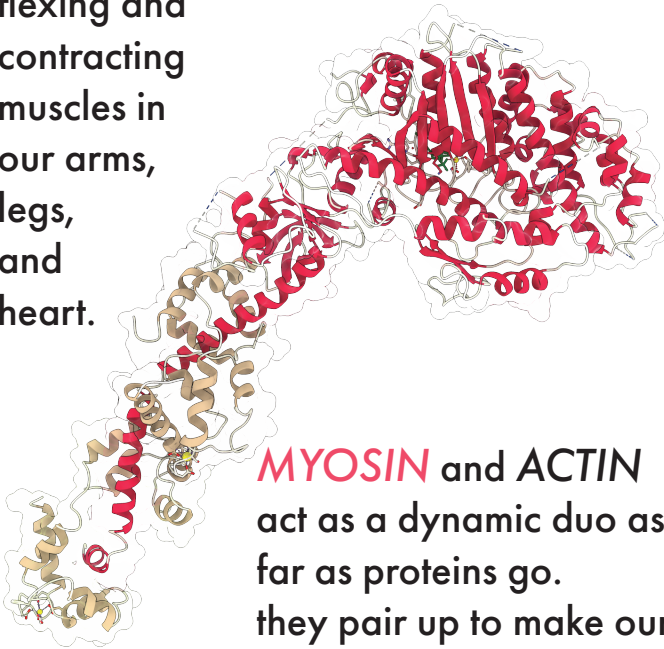
Argopecten irradians (Bay scallop)



Art: Lecturio

Proteins
help you
flex muscles!

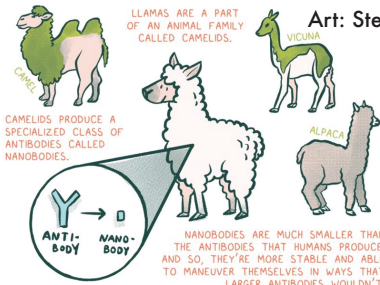
in our bodies,
proteins play a major part,
flexing and
contracting
muscles in
our arms,
legs,
and
heart.



MYOSIN and **ACTIN**
act as a dynamic duo as
far as proteins go.
they pair up to make our
muscle movements flow.

NANOBODY

Vicugna pacos (Alpaca)



Proteins from Alpacas and Camels help fight disease!

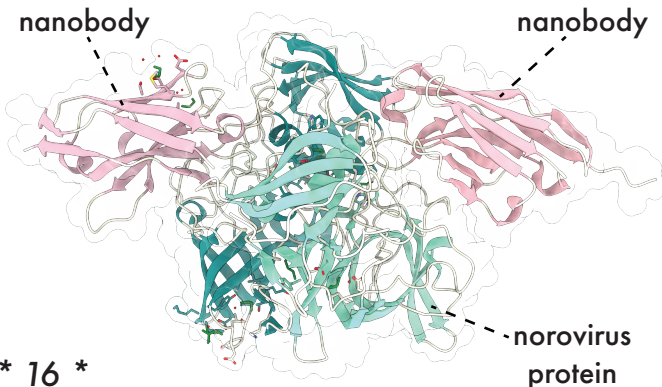
in a microscopic world
where bugs and germs hide

NANOBOBIES

surveil to help us survive.

they seek out antigens
from troublemakers grim,
protecting completely

from diseases we get on a whim.

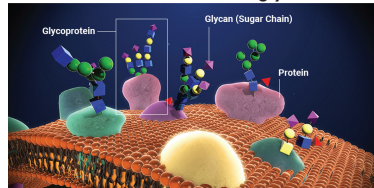


O-GLCNAC TRANSFERASE

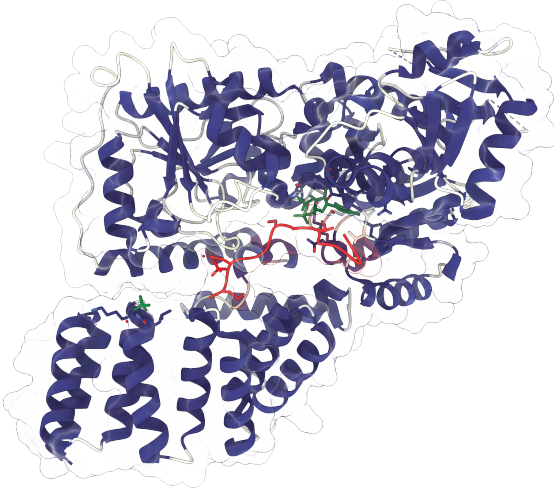
Homo sapiens (Humans)

gly-tech.com

Proteins wear
sugar hats for
structure, function
and stability!

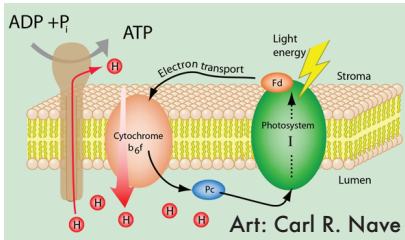


O-GLCNAC TRANSFERASE
orchestrates a magical dance
adding sugars, called glycans,
to proteins by chance.



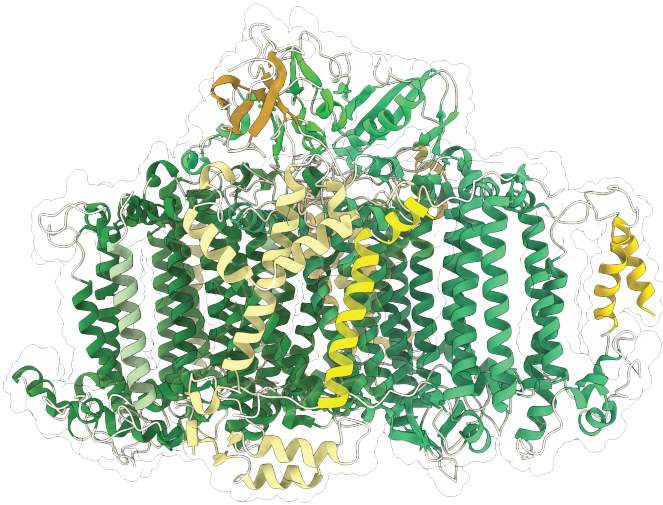
PHOTOSYSTEM I

Synechococcus elongatus
(Cyanobacterium)



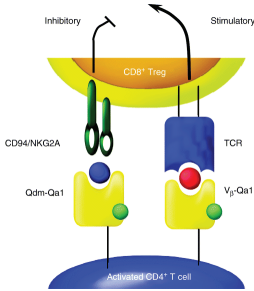
Proteins
harvest
light for
energy!

in nature's grand design you can behold,
PHOTOSYSTEM I functioning bold.
it harvests light for plants to grow
helping photosynthesis with electron flow!



QA-1

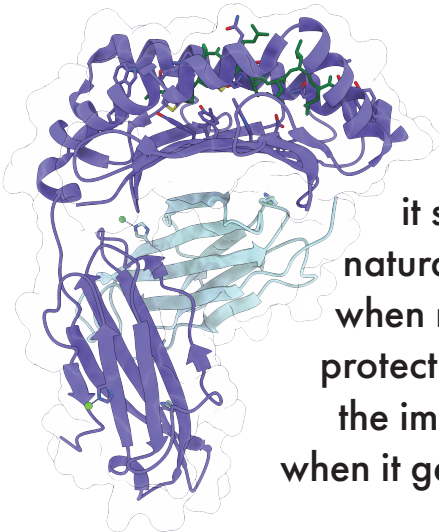
Mus musculus (Mouse)



Proteins protect healthy cells from being attacked by the immune system

Lu et al. Immunological Reviews (2006)

the body's defense is tried and true.
it contains a protein called **QA-1**
that knows just what to do.

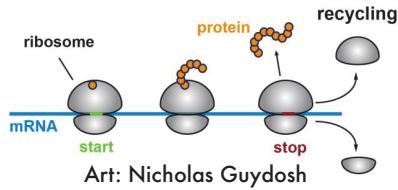


it signals to natural killer cells when not to attack, protecting cells from the immune system when it gets side-tracked.

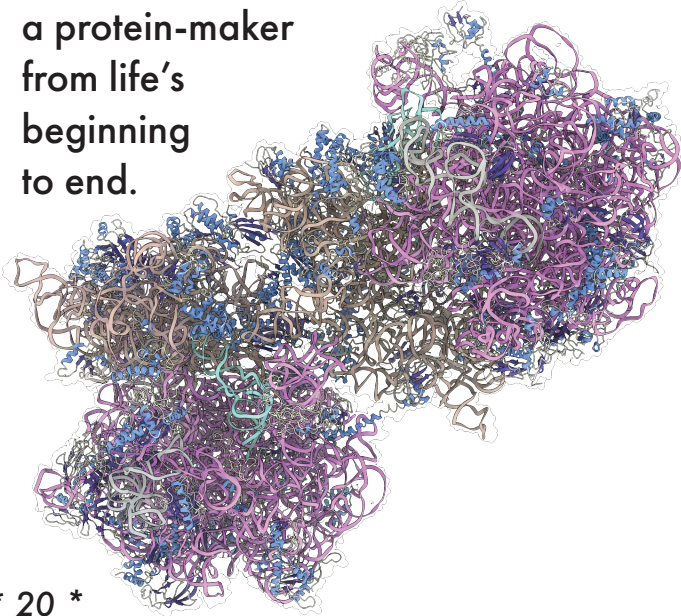
RIBOSOME

Thermus thermophilus
(Thermophilic Bacteria)

Proteins help
make other
proteins!

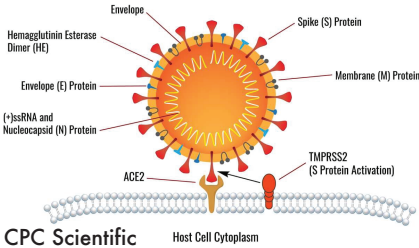


in every cell is a wonder unseen,
a complex factory that's very pristine.
the **RIBOSOME**'s job
is to build and mend, functioning as
a protein-maker
from life's
beginning
to end.



SARS-COV-2 SPIKE

Severe acute respiratory syndrome-related coronavirus



Viruses use proteins to invade our cells

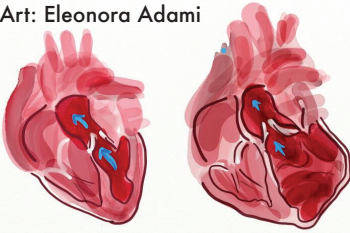
coronaviruses wear **SPIKE** protein on their outside just like a crown, interacting with **ACE2** protein on our cells when infection is going down.



TITIN

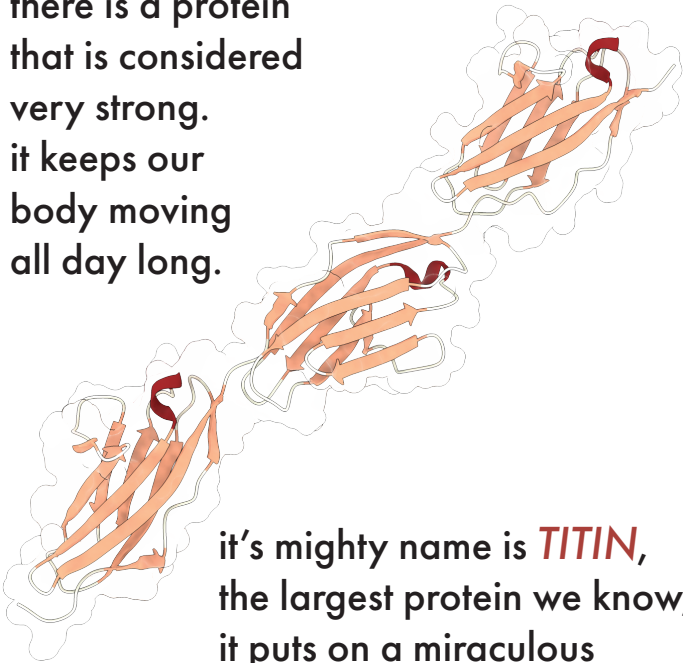
Oryctolagus cuniculus
(European rabbit)

Art: Eleonora Adami



Proteins regulate
heart beats!

in the heart
there is a protein
that is considered
very strong.
it keeps our
body moving
all day long.

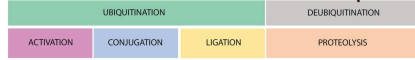


it's mighty name is **TITIN**,
the largest protein we know,
it puts on a miraculous
muscle contracting show!

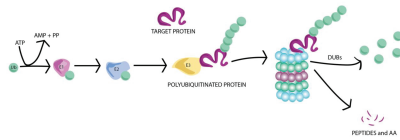
UBIQUITIN

Homo sapiens (Humans)

Bachiller et al. Int. J. Mol. Sci. (2020)



Proteins help
degrade and
recycle other
proteins!

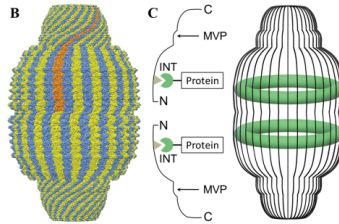


when proteins reach
the end of their life, beware!
UBIQUITIN tags them with care,
marking them for the
proteasome's destructive lair.

VAULT

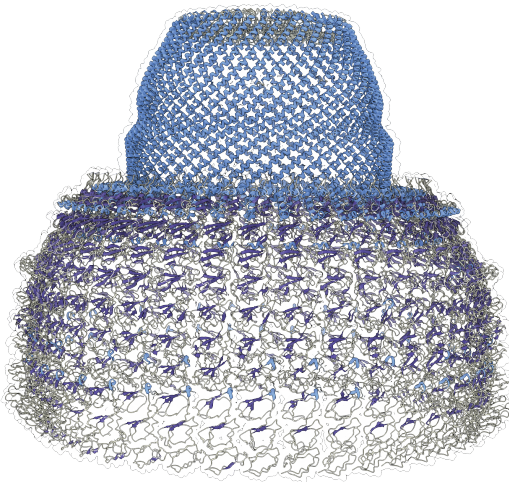
Rattus norvegicus
(Brown Rat)

Proteins help
keep cell
cargo
safe!



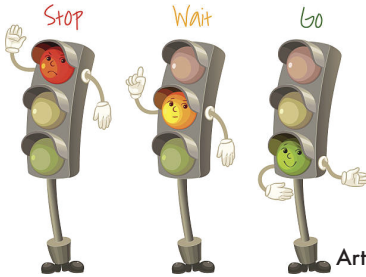
Wang et al. Protein Scaffolds (2018)

just like money locked up in a bank
cells use **VAULT** protein
to protect precious cargo
from their inevitable fate



WNT

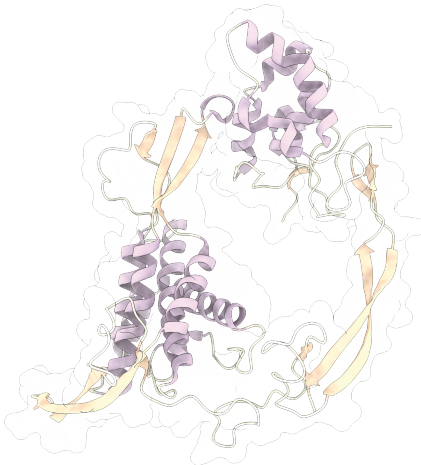
Homo sapiens (Humans)



Proteins are
stop, wait, or
go signals for
the cell!

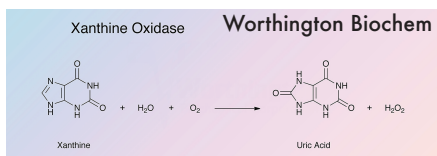
Art: Lyudmyla Kharlamova

WNT acts as a secret spy,
helping cells communicate
making sure they comply.
sending specialized signals
in a magical way
it guides growth and development
each day!



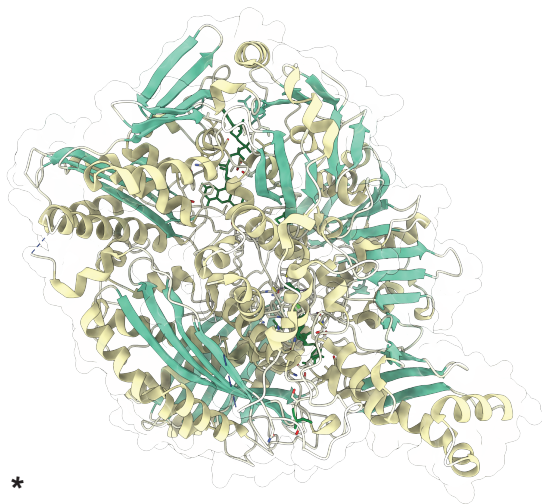
XANTHINE OXIDOREDUCTASE

Bos taurus (Cow)



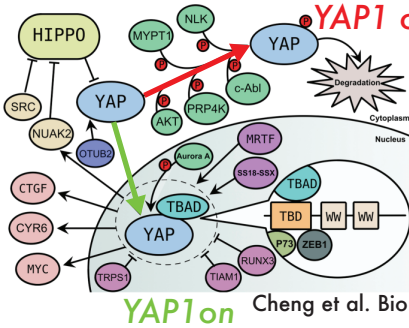
Proteins help
with breaking
down food!

XANTHINE OXIDOREDUCTASE,
*a name that's a mouthful,
breaks down purines in food
with metabolic might
to ensure levels of molecules
in our body stay just right.*



YAP1

Homo sapiens (Humans)



Proteins help cells grow and expand!

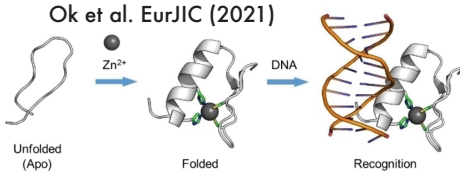
in the *HIPPO* signaling pathway
YAP1 reigns supreme

working with other proteins in a team.
with a shake of its strands it signals repair,
keeping our cells alive with love and care!



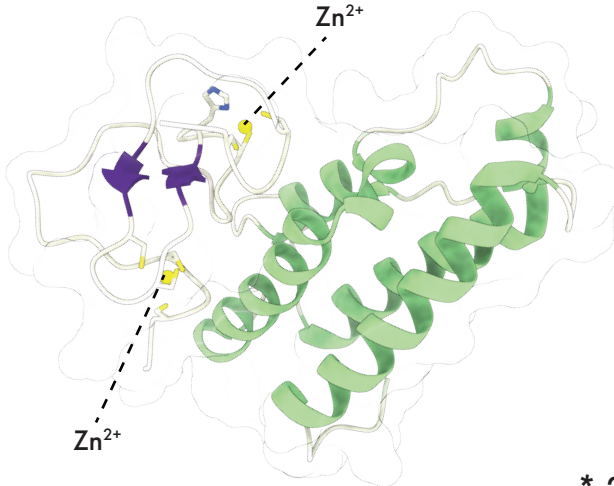
ZINC FINGERS

Homo sapiens (Humans)



Proteins bind metals for their function!

metals lock into **ZINC FINGERS**
like a special key
helping proteins fold to bind DNA
unlocking the hidden secrets
of you and me.



REFERENCES

* All protein cartoons illustrated with ChimeraX v1.5

* Many targets were chosen
from Protein Data Bank's Molecule of the Month

* The book was inspired by Chu Wai Liew's
"My Little Alphabet Book of Proteins"

FRONT COVER:

* Calmodulin*
PDB ID 1MXE

CELLULOSE SYNTHASE

PDB ID 6WLB

Purushotham et al. Science. 2020

INTRO:

DNA
PDB ID 3PVX

DNA POLYMERASE

PDB ID 1TAU

Eom et al. Nature. 1996

CYSTATIN C

PDB ID 3GAX

ESTROGEN RECEPTOR

PDB ID 1A52

Tanenbaum et al. PNAS. 1998

APOPTOSOME

PDB ID 3J2T

FIBRIN

PDB ID 1M1J

Yang et al. Biochemistry. 2001

APOLIPOPROTEIN A-I

PDB ID 1AV1

FEATURED PROTEINS

* ANTIFREEZE*

PDB ID 1WFB

Sicheri et al. Nature. 1995

*G PROTEIN-

COUPLED RECEPTOR*

PDB ID 2RH1

Cherezov et al.

Science. 2007

* BETA-GALACTOSIDASE *

PDB ID 1JZ8

Juers et al. Biochemistry. 2001

HEMOGLOBIN

PDB ID 2HHB

Fermi et al.

J Mol Biol. 1984

To view structures visit: <https://www.rcsb.org/>

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INTERFERON

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Karpusas et al.
PNAS. 1997

JUN A 1

PDB ID 1PXZ

Czerwinski et al.
J Biol Chem. 2005

KAI A

PDB ID 1R8J

Ye et al.
J Biol Chem. 2004

LYSOZYME

PDB ID 1LYD

Rose et al.
Protein Eng. 1988

MYOSIN

PDB ID 1B7T

Houdusse et al.
Cell. 1999

NANOBODY

PDB ID 6XW5

Koromyslova et al.
J Virol. 2020

O-GLCNAC TRANSFERASE

PDB ID 3PE4

Lazarus et al.
Nature. 2011

PHOTOSYSTEM I

PDB ID 1JBO

Jordan et al.
Nature. 2001

Qa-1

PDB ID 3VJ6

Zeng et al. J Immunol 2012

RIBOSOME

PDB ID 4V5D

Voorhees et al.
Nat Struct Mol Biol. 2009

SARS-COV-2 SPIKE

PDB ID 6CRZ

Kirchdoerfer et al.
Sci Rep. 2018

TITIN

PDB ID 2RIK

von Castelmur et al.
PNAS. 2008

UBIQUITIN

PDB ID 1UBQ

Vijay-Kumar et al.
J Mol Biol. 1987

VAULT

PDB ID 4V60

Tanaka et al. Science. 2009

WNT

PDB ID 6AHY

Hirai et al.
Nat Struct Mol Biol. 2019

XANTHINE OXIDOREDUCTASE

PDB ID 1FO4

Enroth et al. PNAS. 2000

YAP1

PDB ID 3KYS

Li et al. Genes Dev. 2010

ZINC FINGERS

PDB ID 6IET

Chen et al. Nat Commun. 2019

* About this book *

PROTEINS are essential to all life on Earth. They have many different functions ranging from cellular structure, transport of molecules, energy storage, cellular growth, metabolism, biological catalysts, to environmental sensing.

PROTEINS are found in all types of organisms from bacteria to plants to humans, and even non-living infectious agents, such as viruses. Determination of **PROTEIN** three-dimensional structures allows scientists to understand their biological function, relevance to disease, and discover their therapeutic applications.

The aim of this book is to introduce aspiring scientists (and non-scientists) of all ages to the wonderful world of **PROTEINS**.

* About the Author *

Dr. McShan is an Assistant Professor at the Georgia Institute of Technology School of Chemistry and Biochemistry. Their research involves characterizing the structure and function of proteins involved in human immune systems.

For more info visit:
<http://mcshanlab.com/>