

Extra Material: Biomolecules

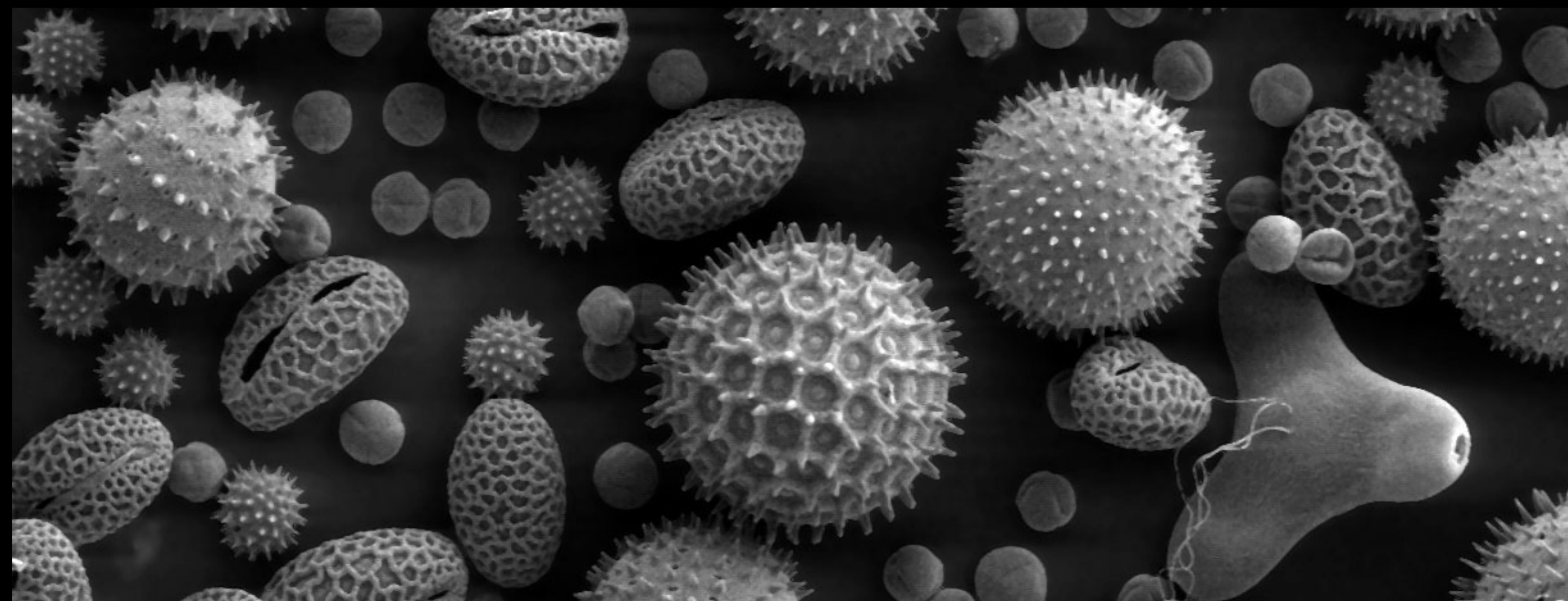
The stuff that makes up living stuff

Biomolecules make up
living matter

(living matter)



From: <https://e360.yale.edu/features/as-oceans-warm-the-worlds-giant-kelp-forests-begin-to-disappear#>

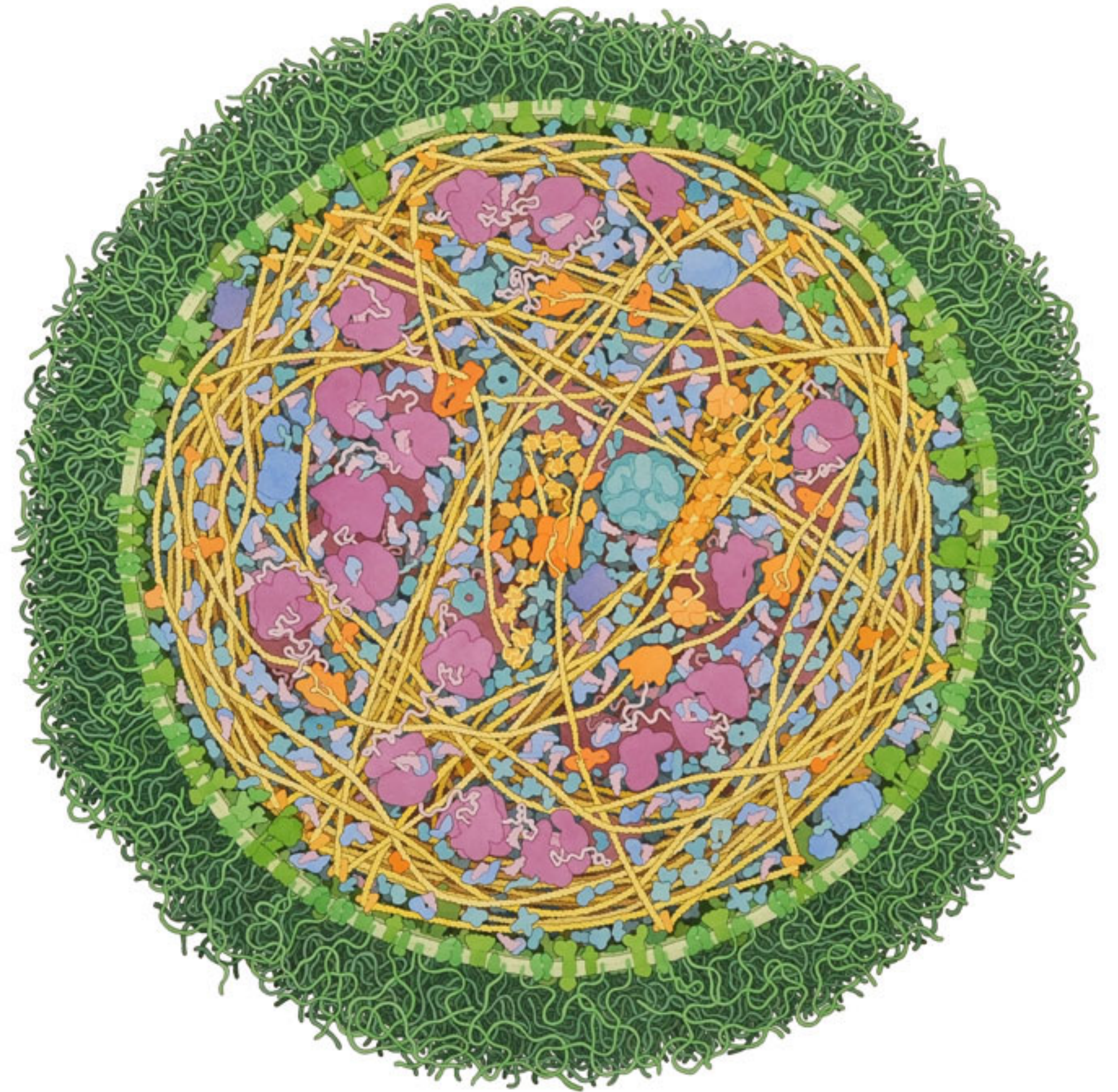


<https://svs.gsfc.nasa.gov/10394>



From: <https://cheezburger.com/6771324928>

Mycoplasma mycoides
(David Goodsell, 2011)



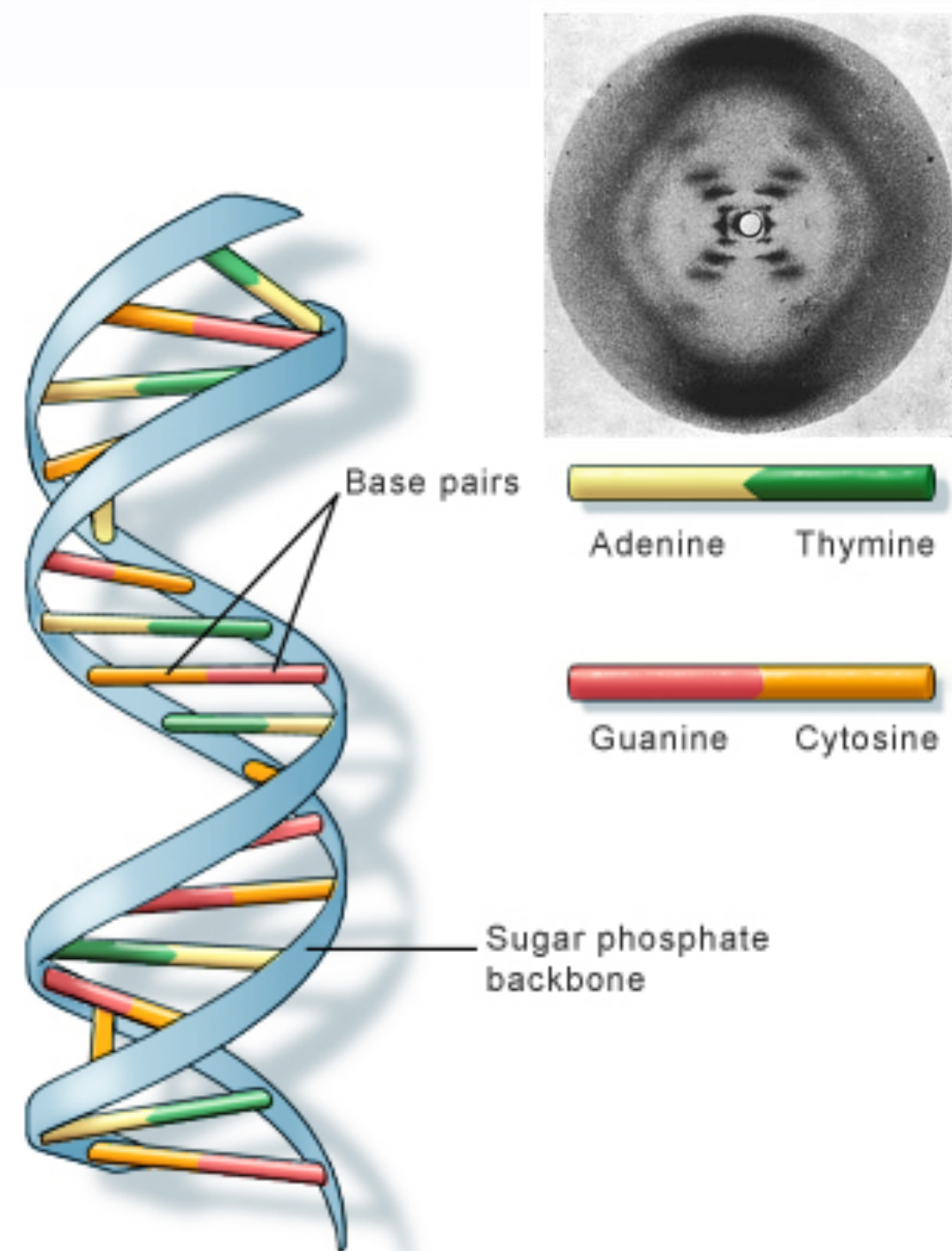
Most biomolecules fall into four classes

nucleic acids

proteins

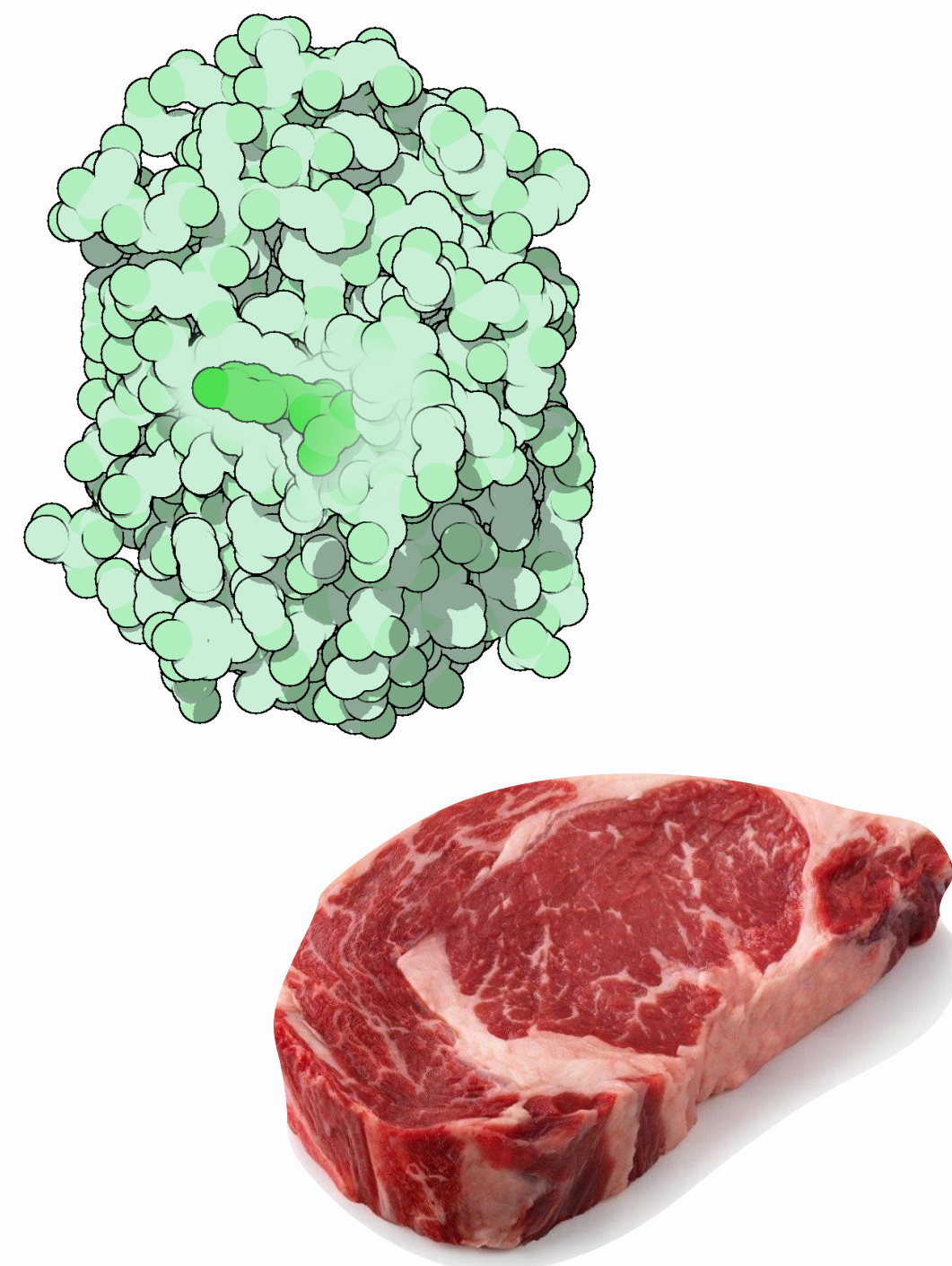
saccharides

lipids



U.S. National Library of Medicine

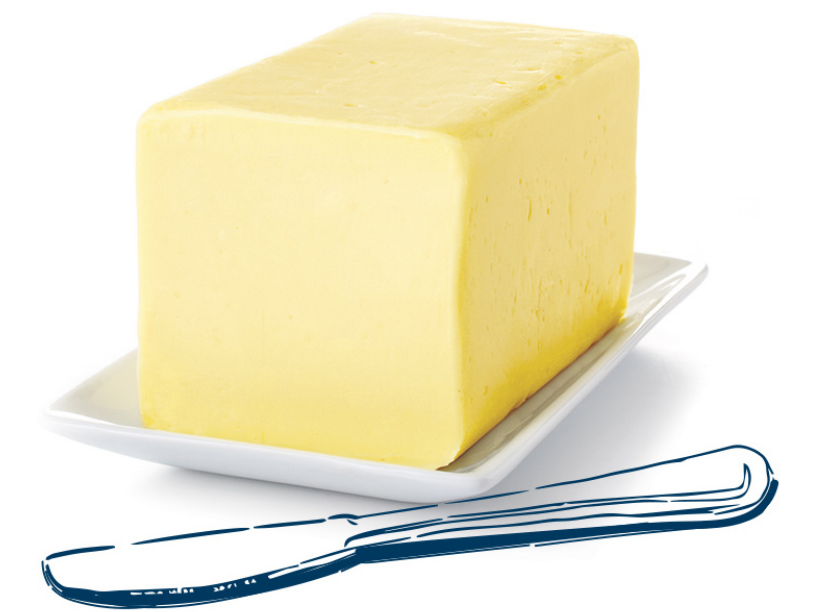
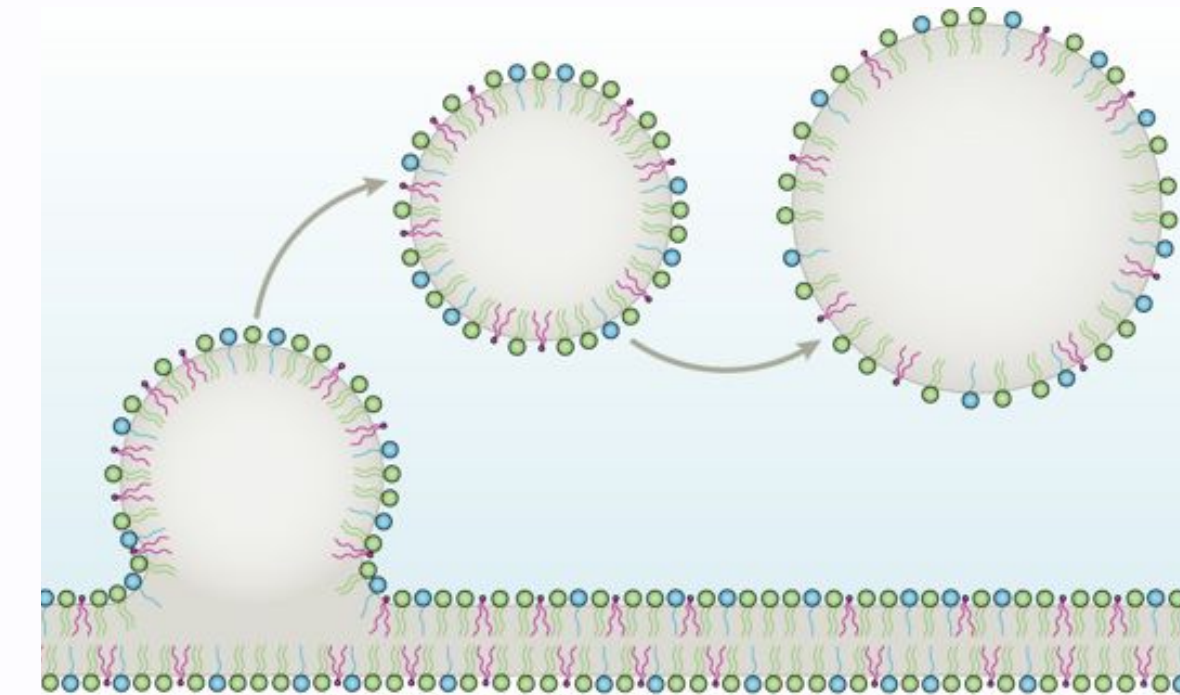
From: NIH (<https://ghr.nlm.nih.gov/primer/basics/dna>)



From: David Goodsell (<https://pdb101.rcsb.org/motm/42>) and Google

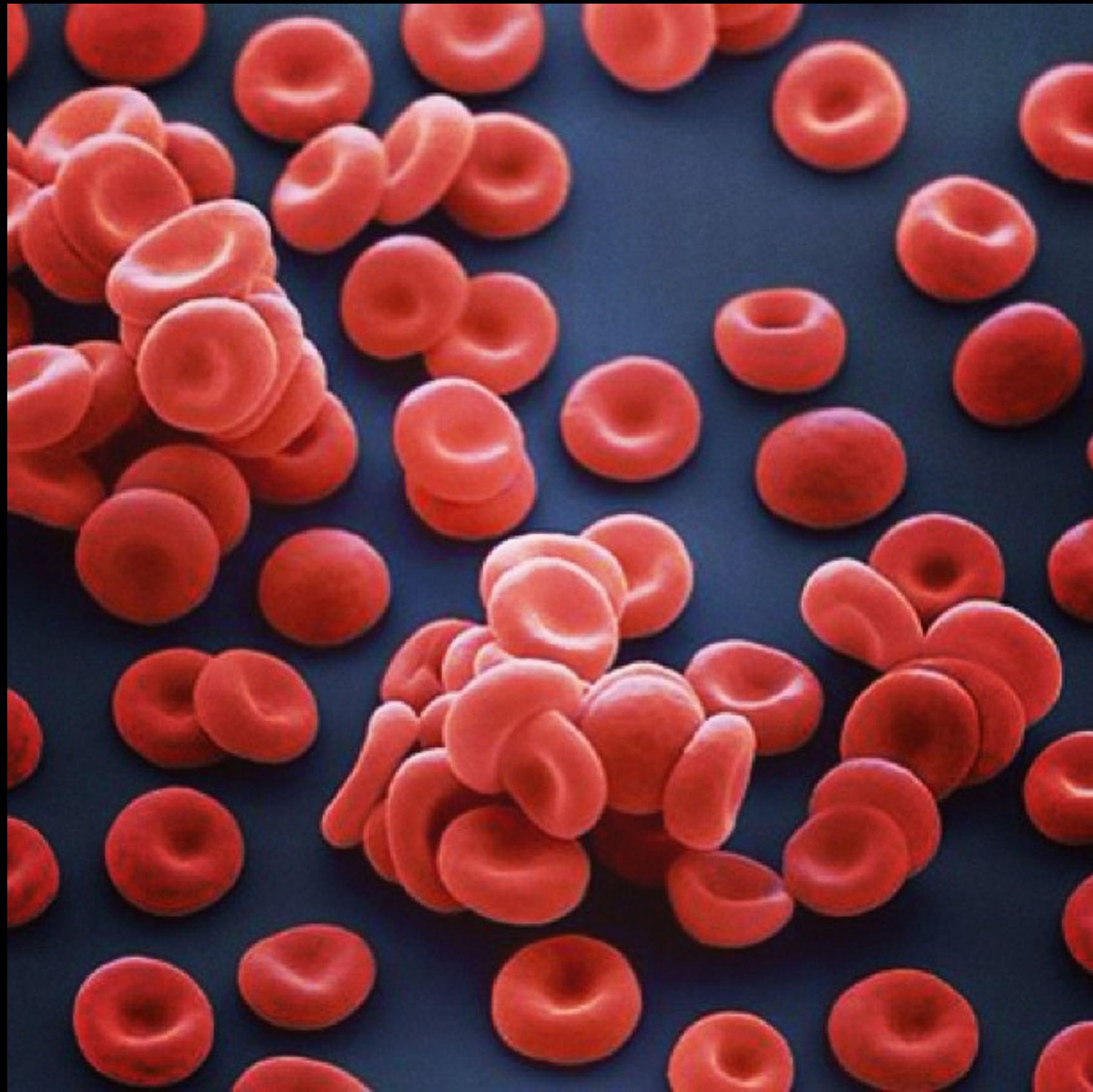


From: SF Chronicle (<https://www.sfchronicle.com/environment/article/Biggest-private-sequoia-grove-to-be-preserved-in-14444748.php>) and Google

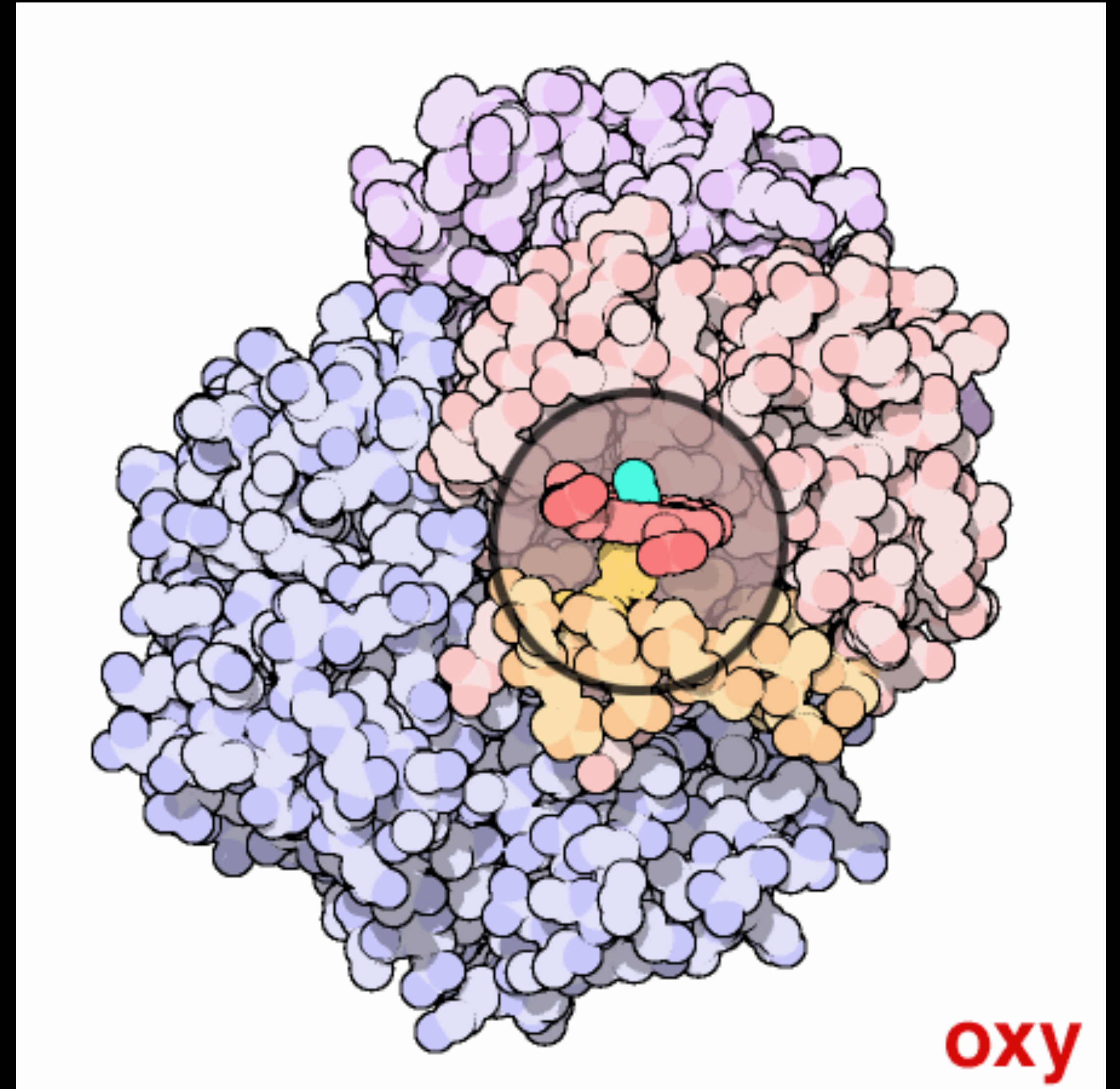


From: Nature (doi.org/10.1038/s41580-018-0037-7) and Google

Biomolecules perform the
basic tasks of biology

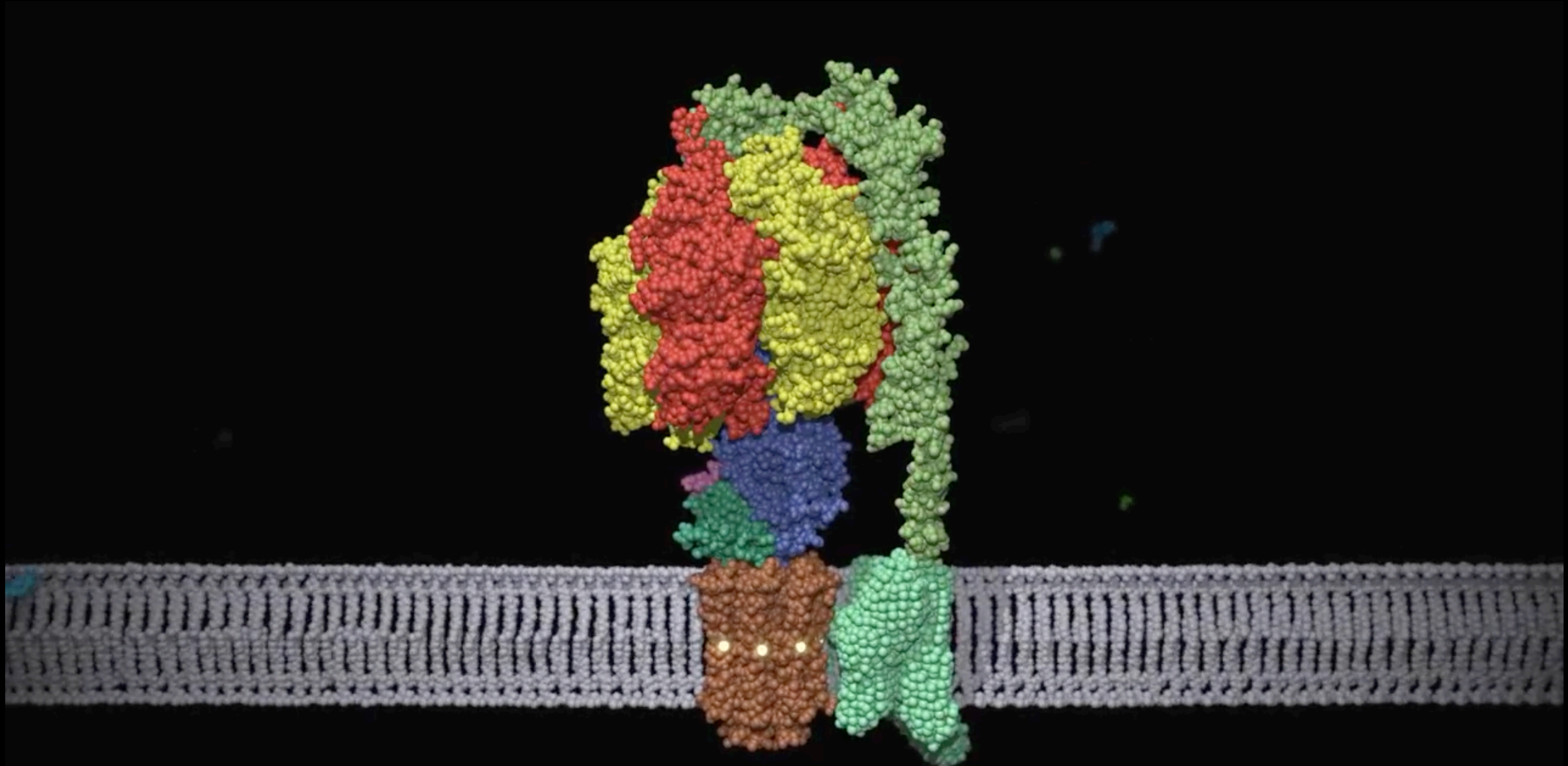


Red blood cells catch oxygen
with a protein called
hemoglobin



From: PDB (<https://pdb101.rcsb.org/motm/41>) and Flickr

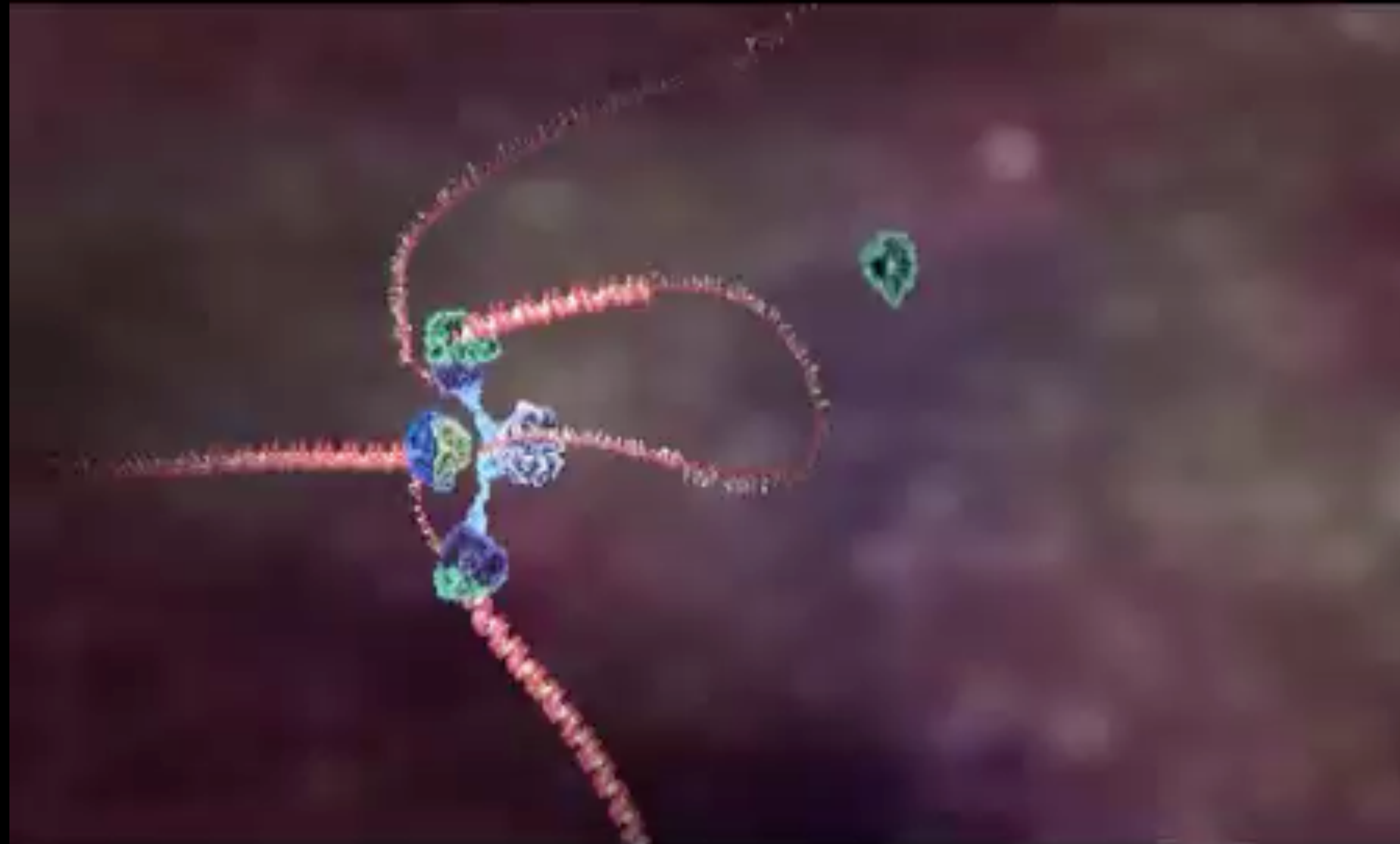
ATP Synthase (complex of proteins) powers cells



From: Stuart Lab (https://www.youtube.com/watch?v=b_cp8MsnZFA&feature=youtu.be&t=53)

DNA replicase (complex of proteins) copies DNA

wehi.edu.au



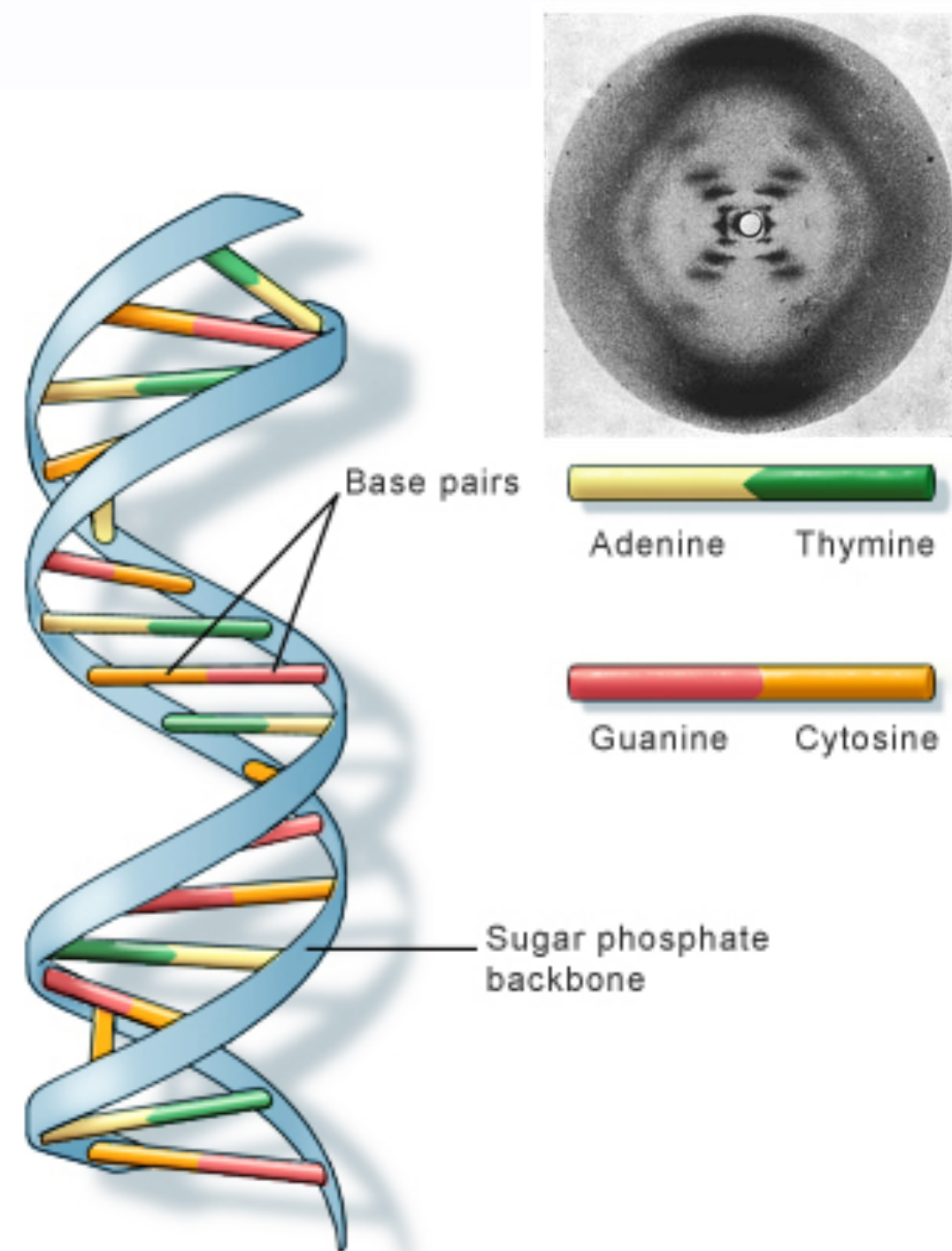
Billions of bio-molecular machines copy your DNA every second

What are biomolecules *made of*?

Most biomolecules are *polymers*



nucleic acids

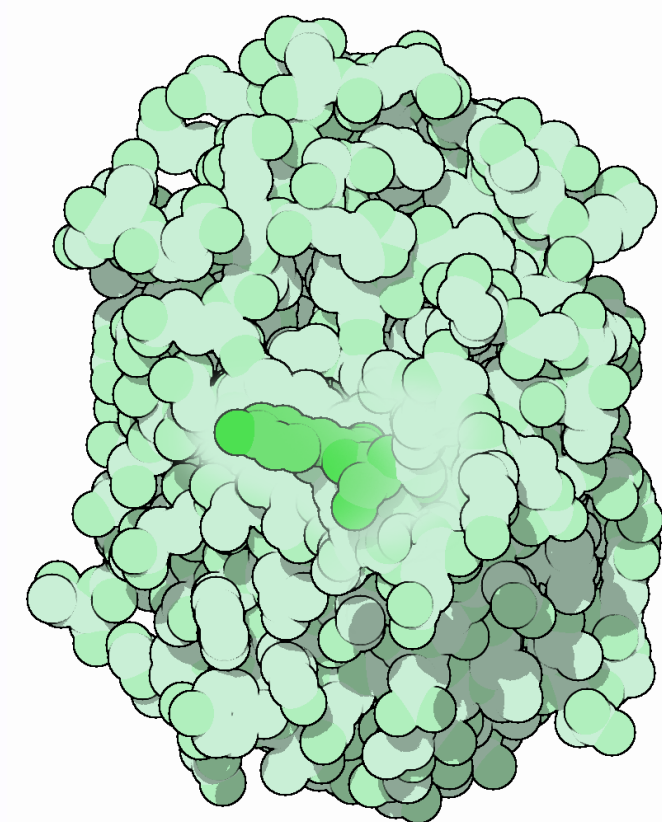


U.S. National Library of Medicine

From: NIH (<https://ghr.nlm.nih.gov/primer/basics/dna>)



proteins



From: David Goodsell (<https://pdb101.rcsb.org/motm/42>) and Google



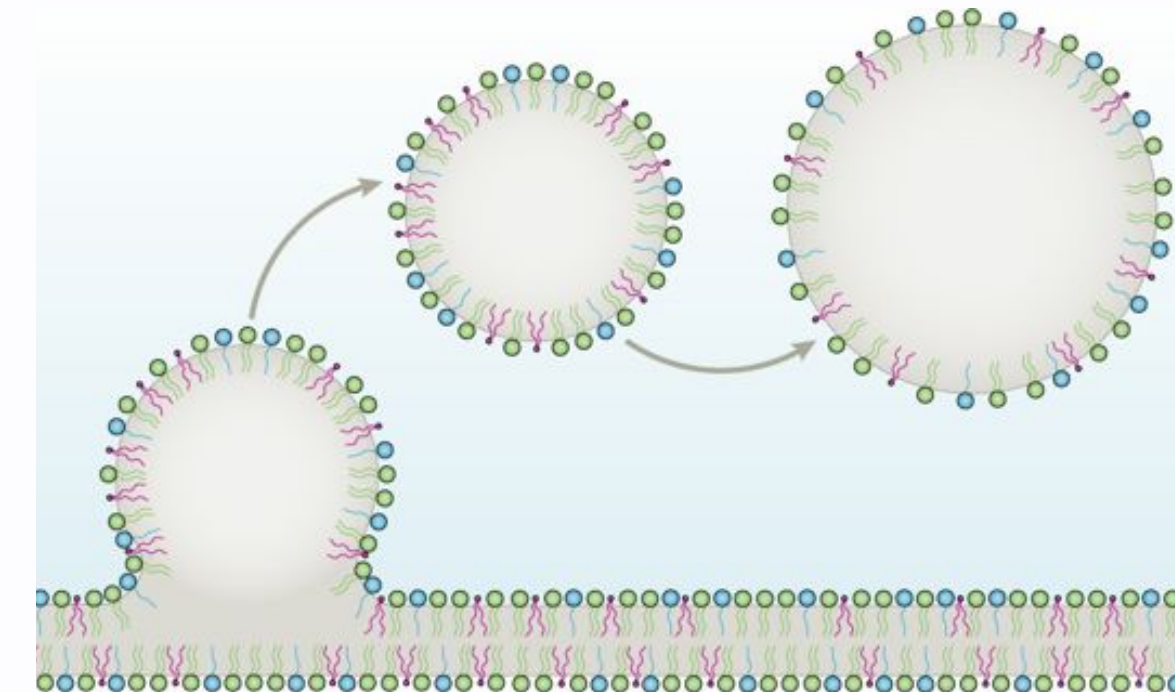
saccharides



From: SF Chronicle (<https://www.sfchronicle.com/environment/article/Biggest-private-sequoia-grove-to-be-preserved-in-14444748.php>) and Google

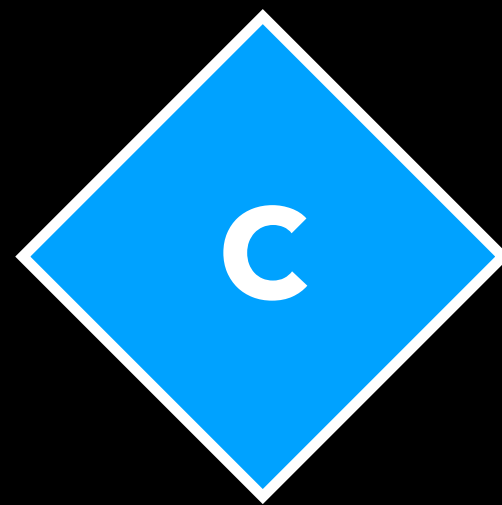
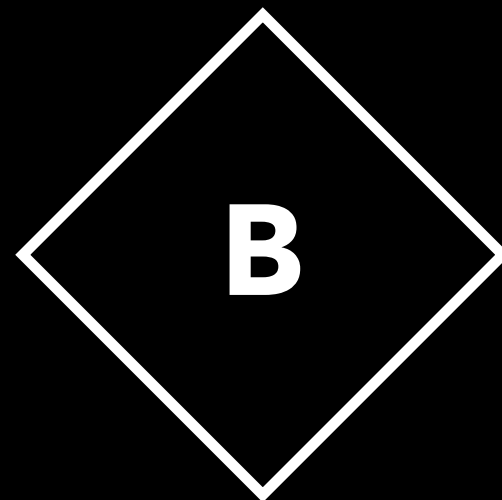
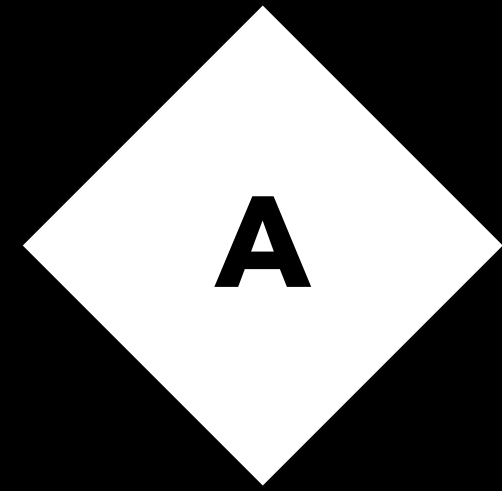


lipids

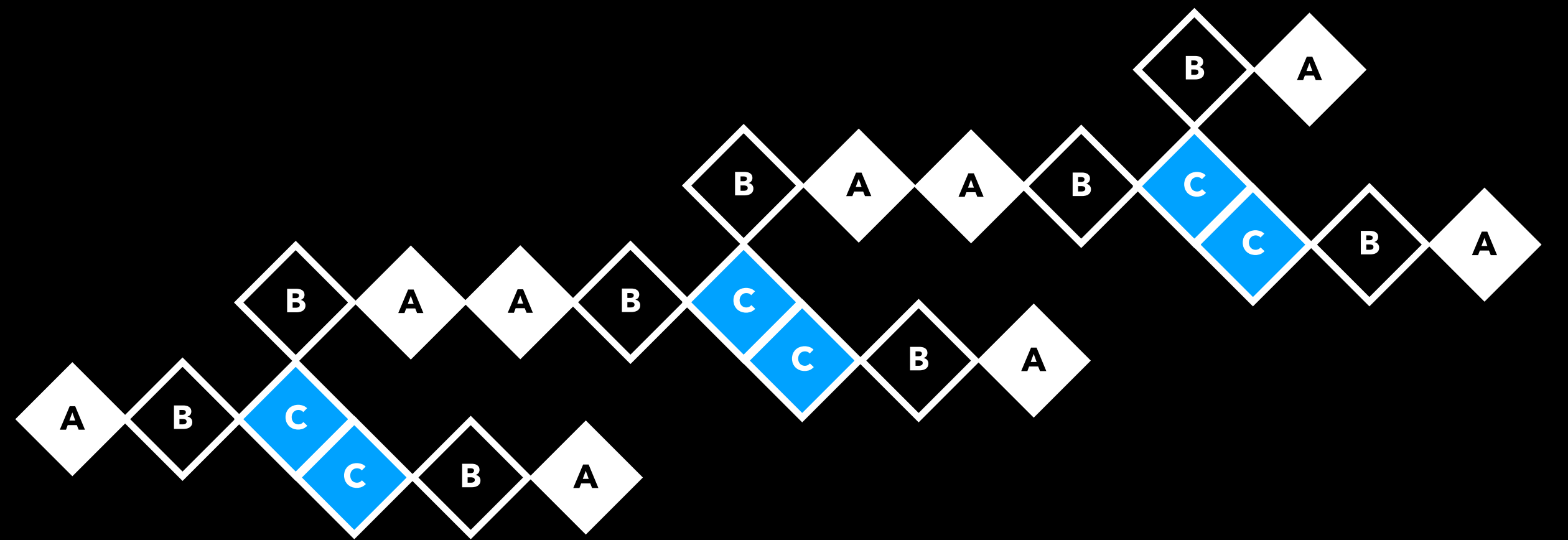
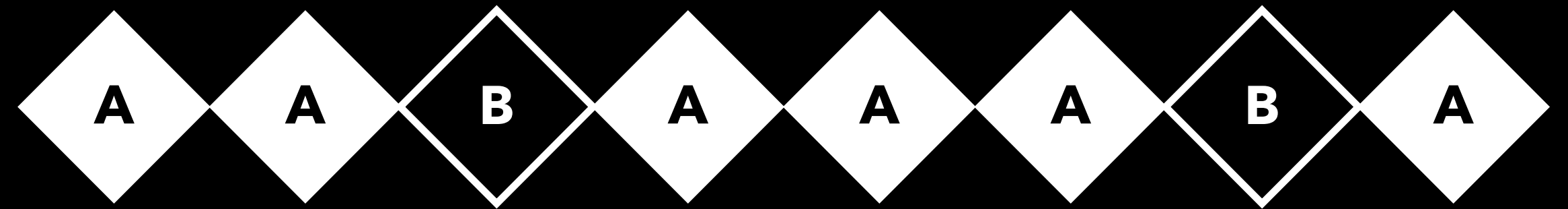


From: Nature (doi.org/10.1038/s41580-018-0037-7) and Google

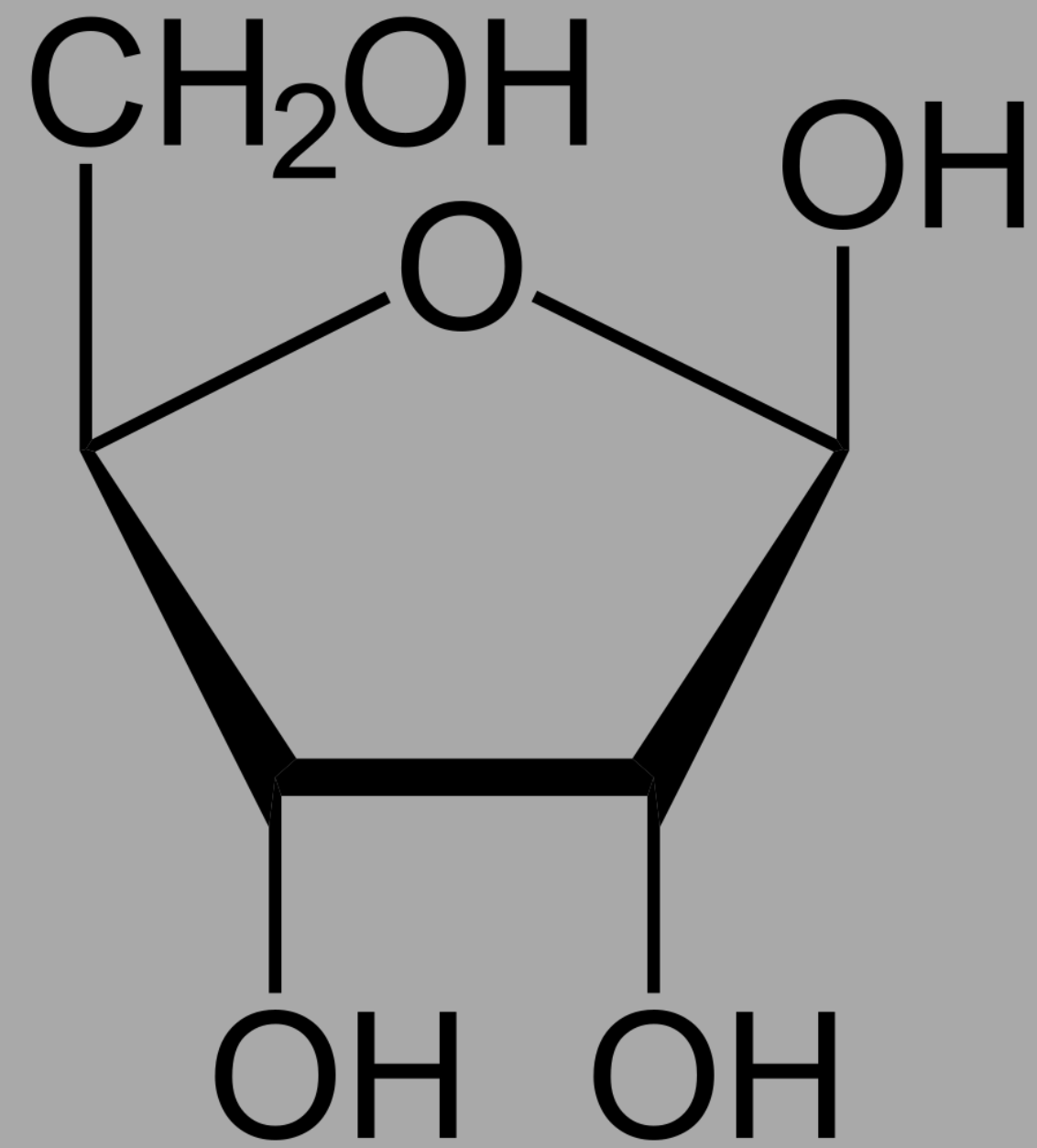
monomers



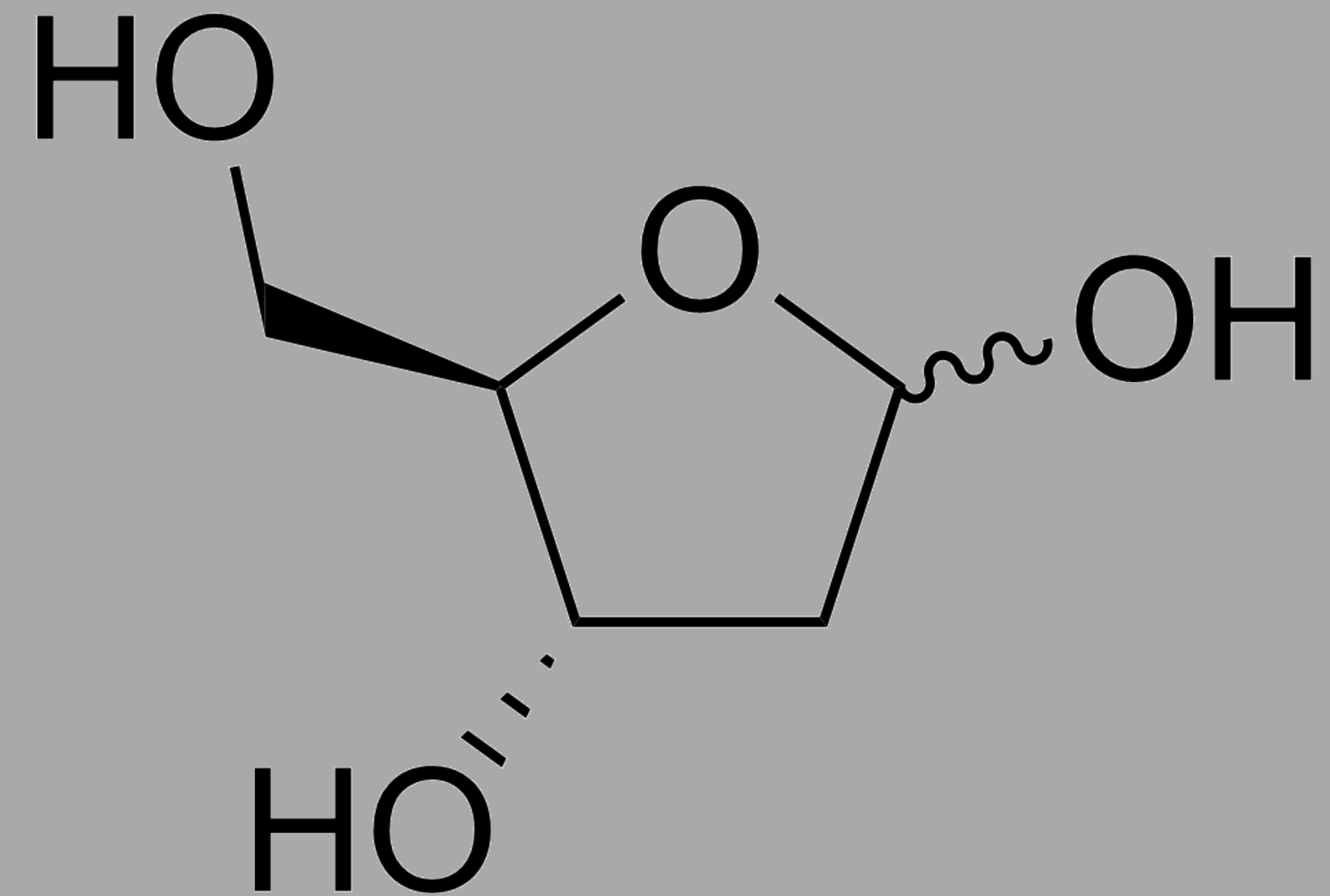
polymers



Polysaccharides are made of monosaccharides

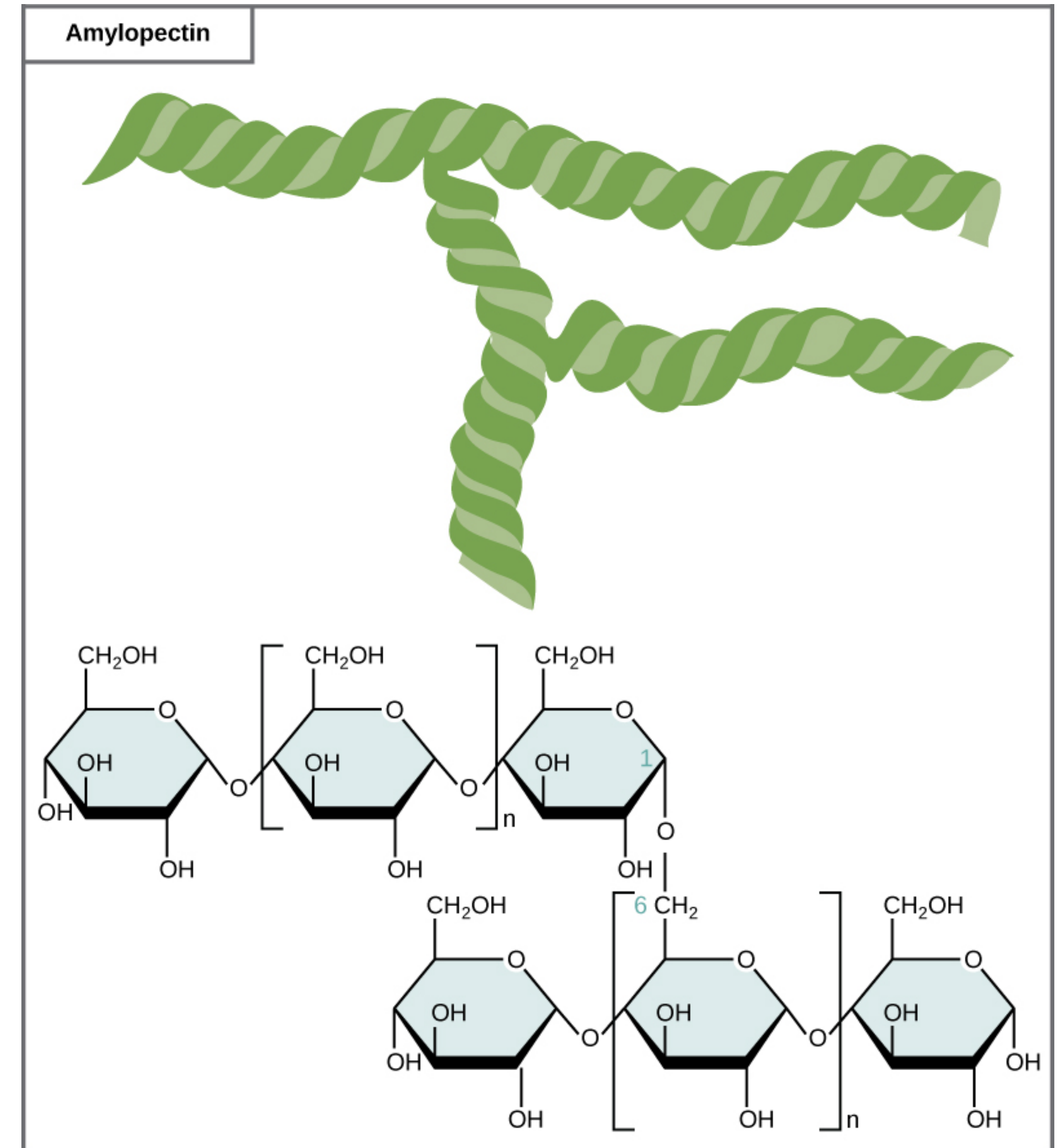
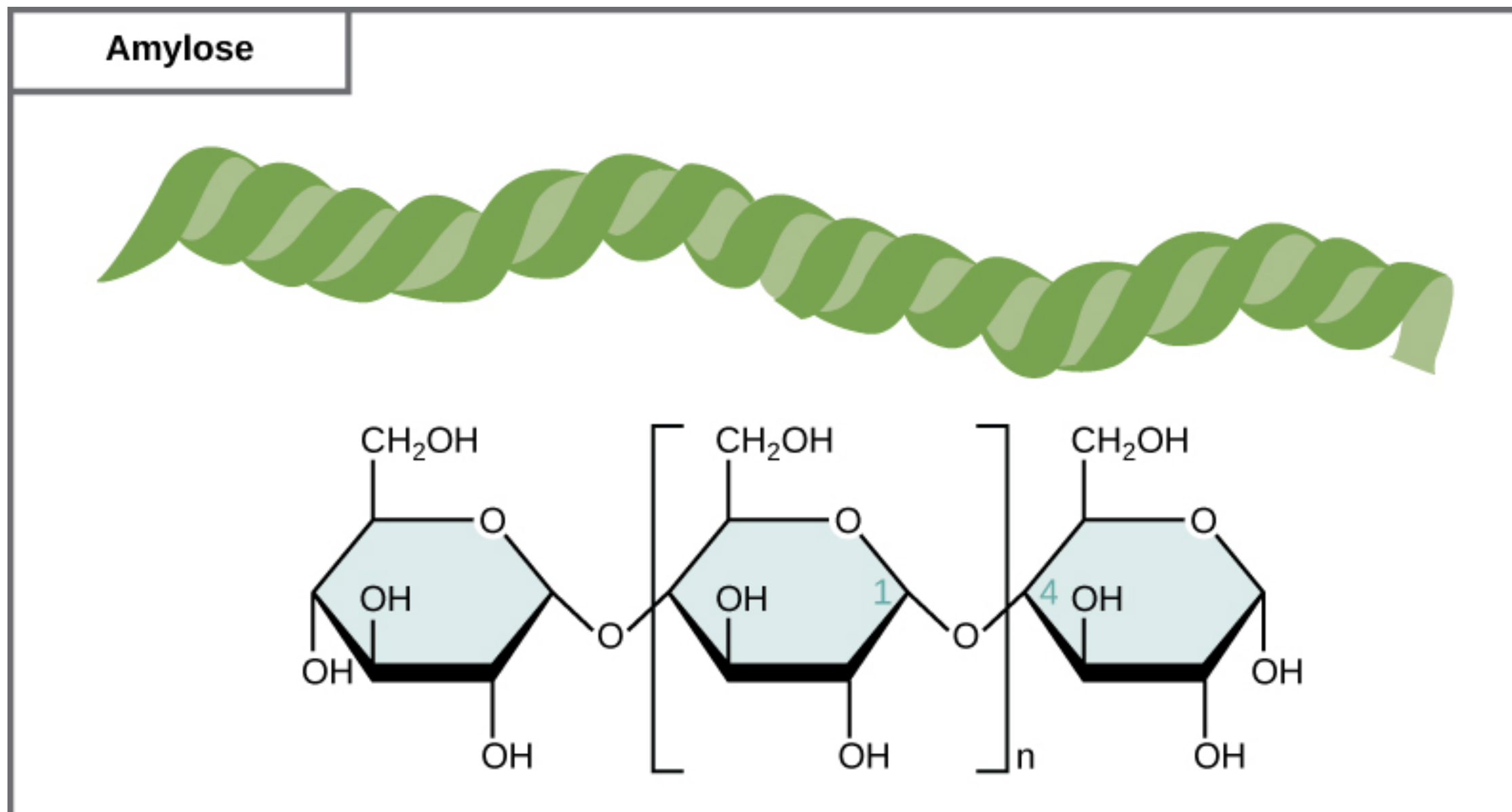


Ribose

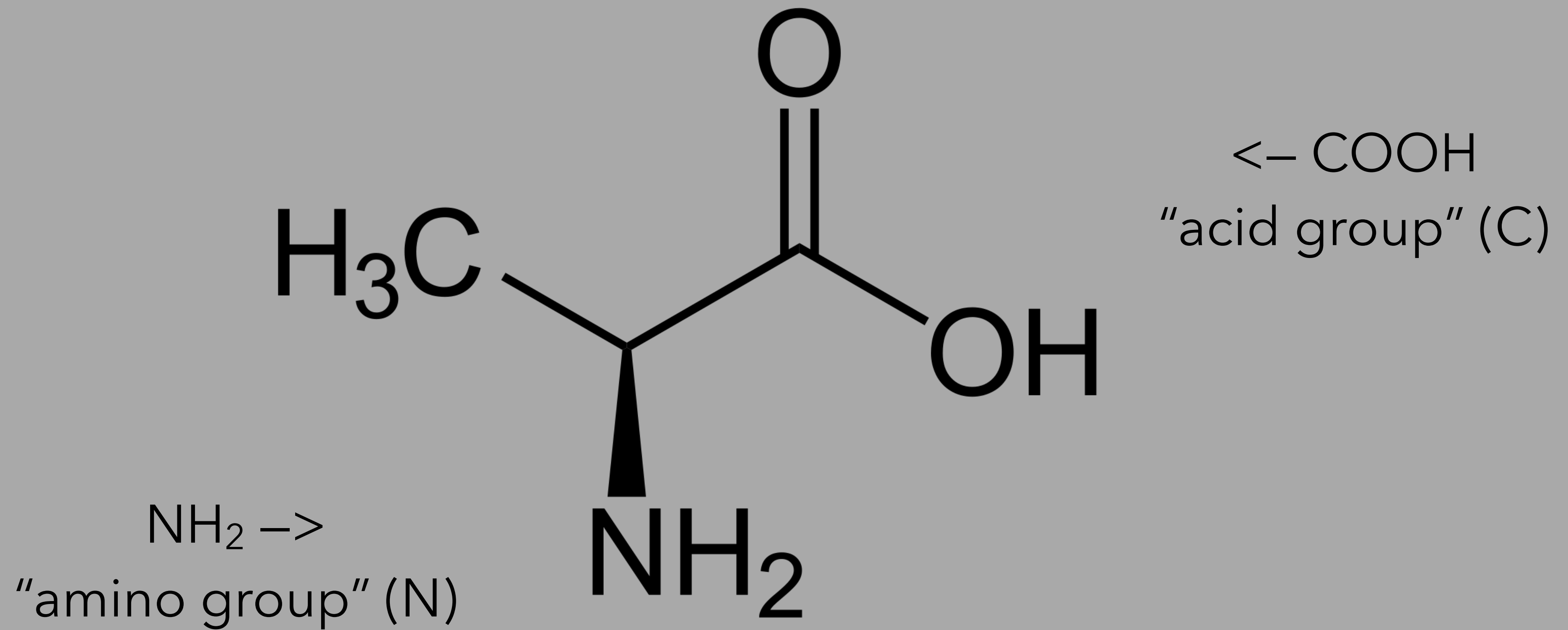


Deoxyribose

Polysaccharides form *straight* or *branched* chains



Proteins are made of amino acids



L-alanine

There are 20 amino acids*

*(kinda, biology makes more kinds of amino acids by modifying these twenty)

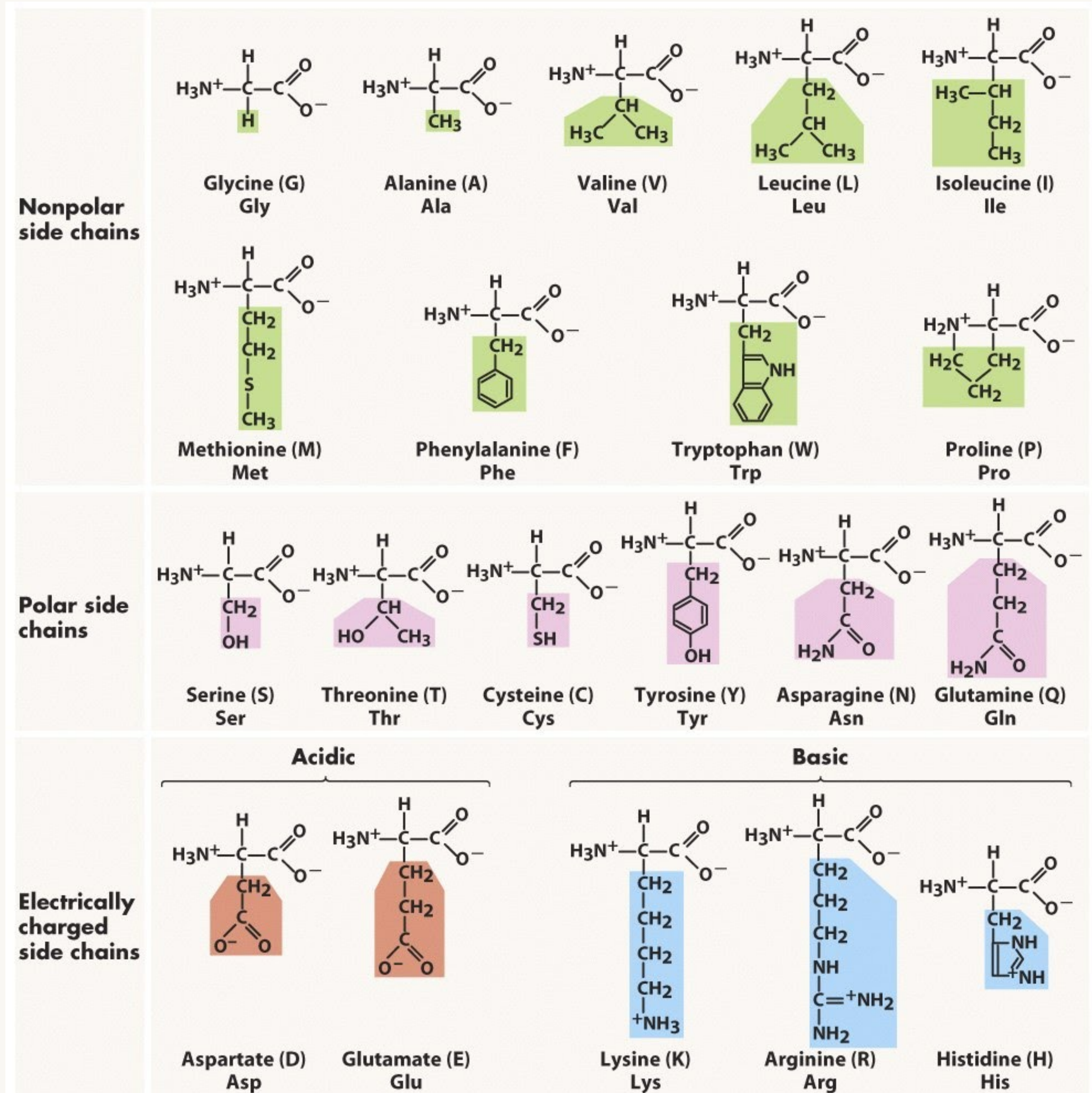
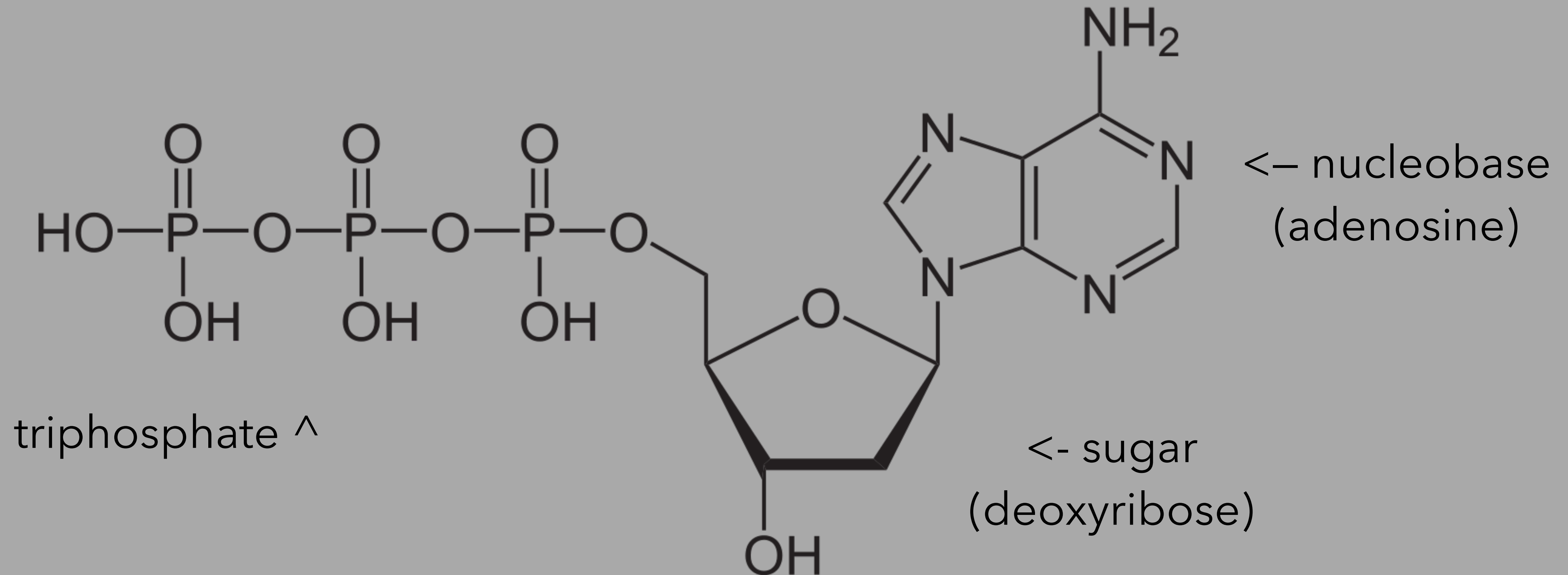


Figure 3-5 Biological Science, 2/e

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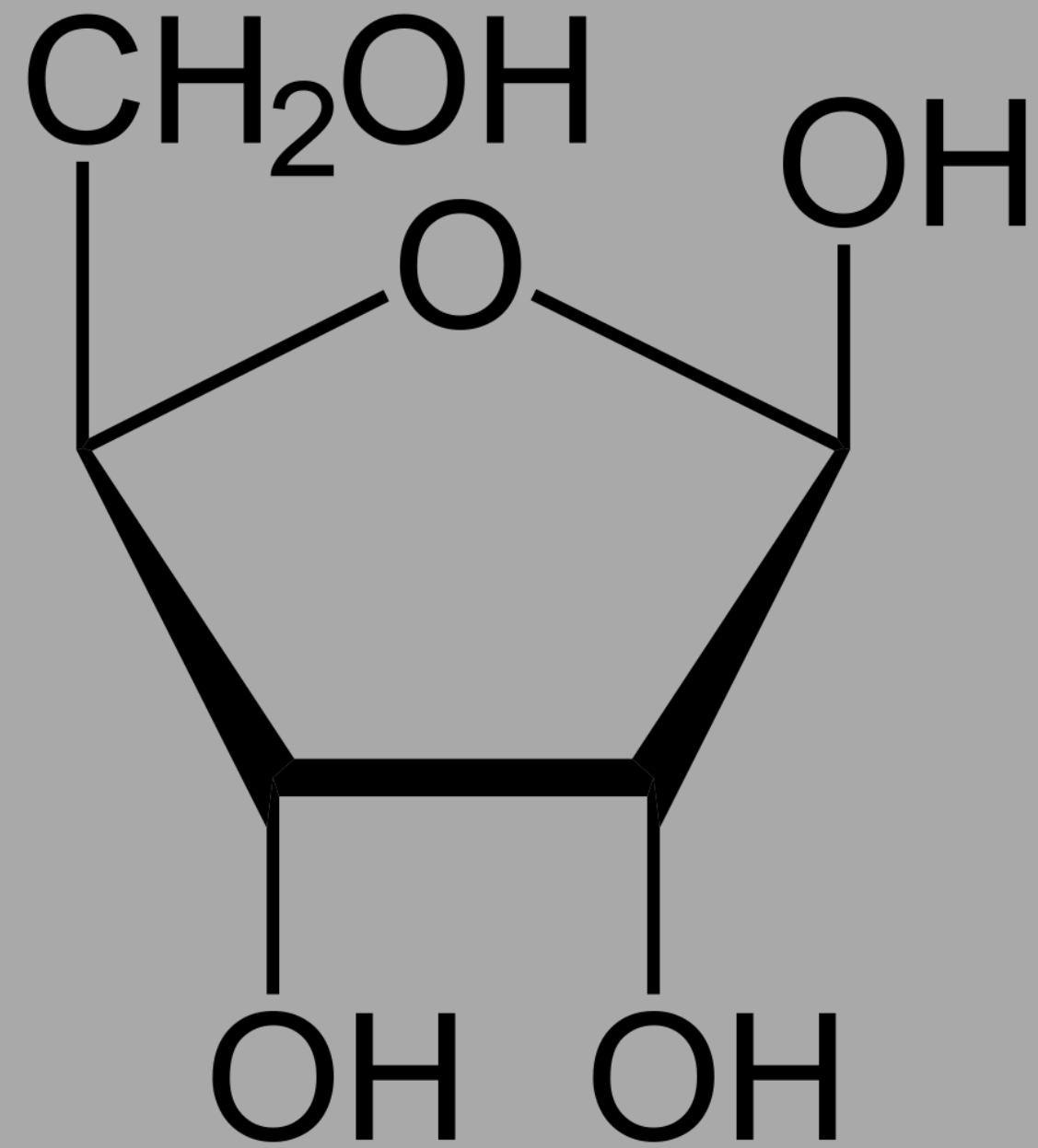
Nucleic acids are made of nucleotides



Deoxyadenosine triphosphate
(dATP)

RNA

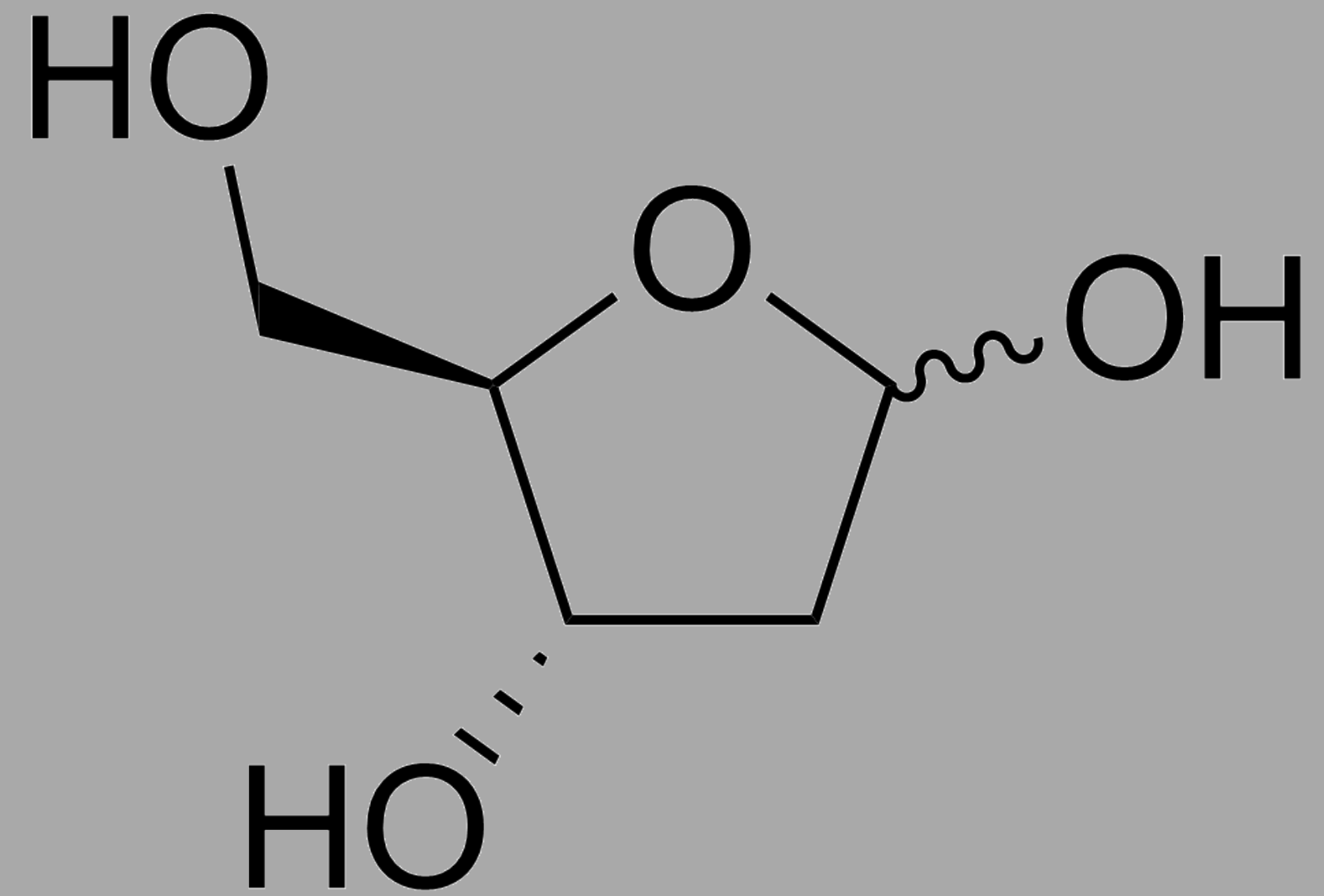
(ribonucleic acid)



Ribose

DNA

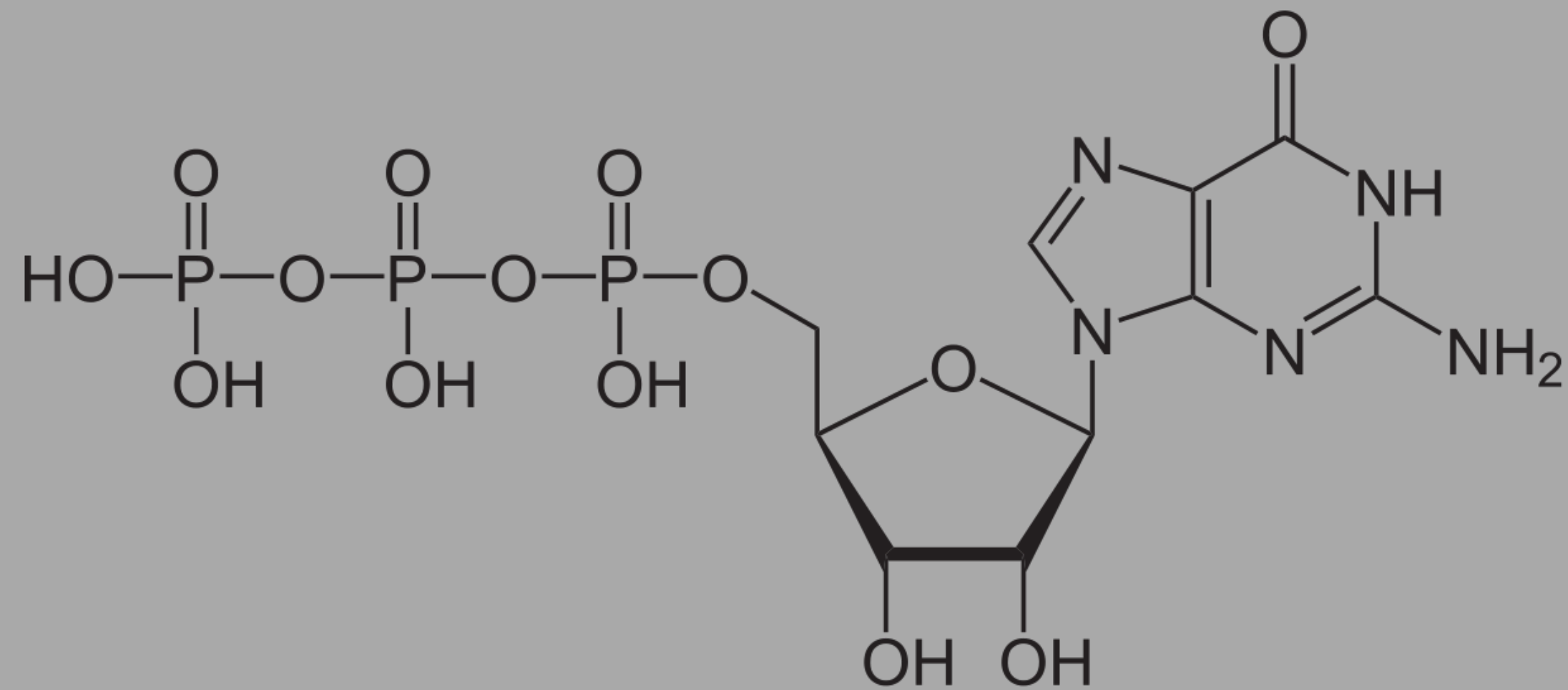
(deoxyribonucleic acid)



Deoxyribose

RNA

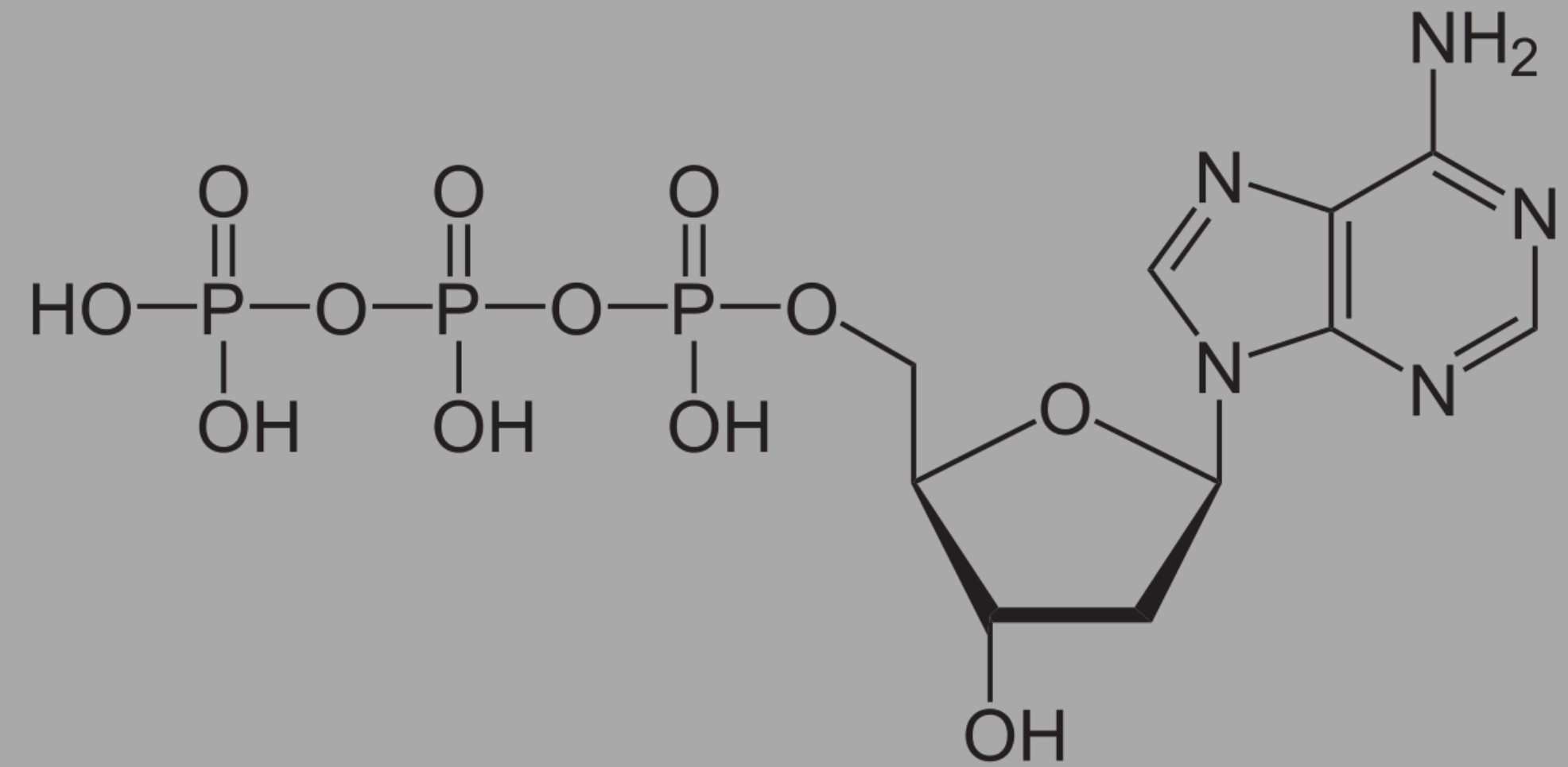
(ribonucleic acid)



rGTP

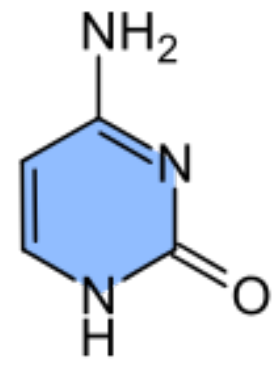
DNA

(deoxyribonucleic acid)

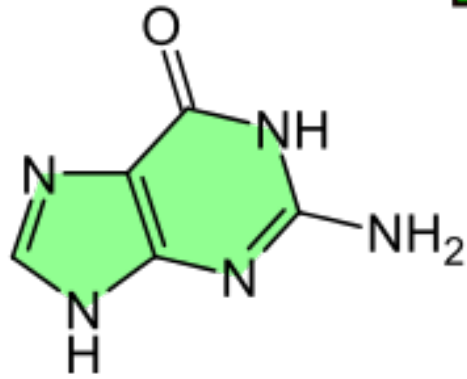


dATP

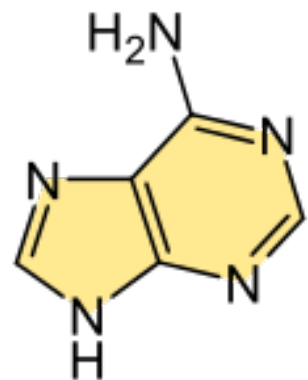
Cytosine **C**



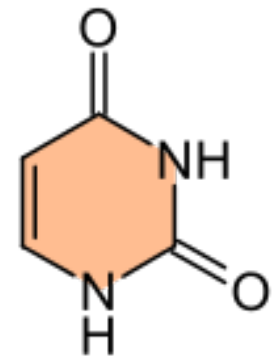
Guanine **G**



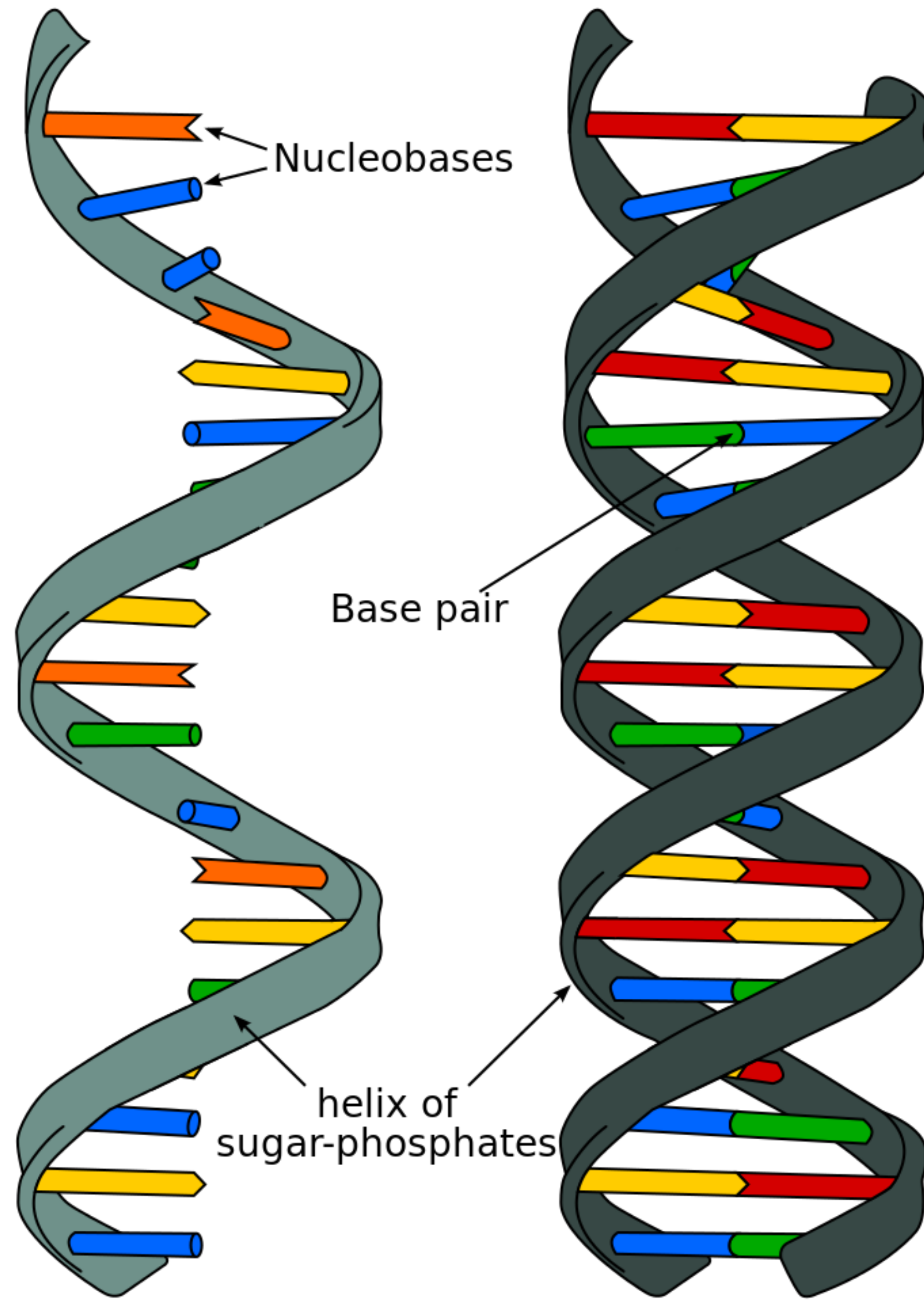
Adenine **A**



Uracil **U**



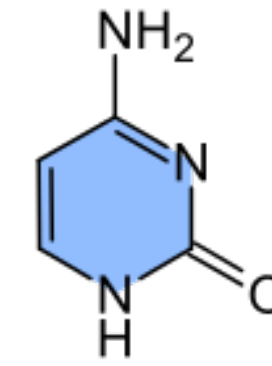
Nucleobases of RNA



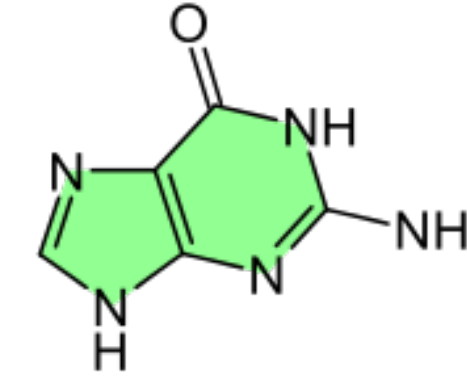
RNA
Ribonucleic acid

DNA
Deoxyribonucleic acid

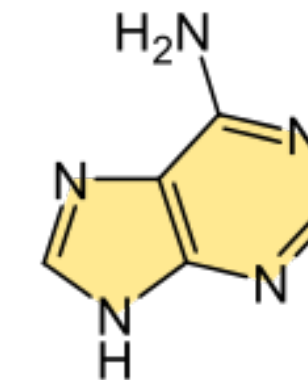
Cytosine **C**



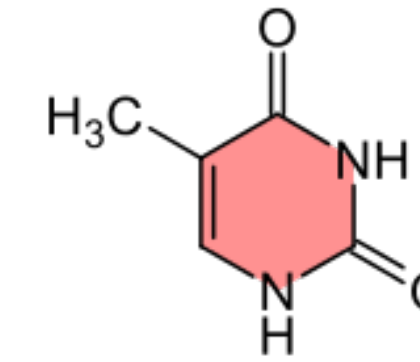
Guanine **G**



Adenine **A**

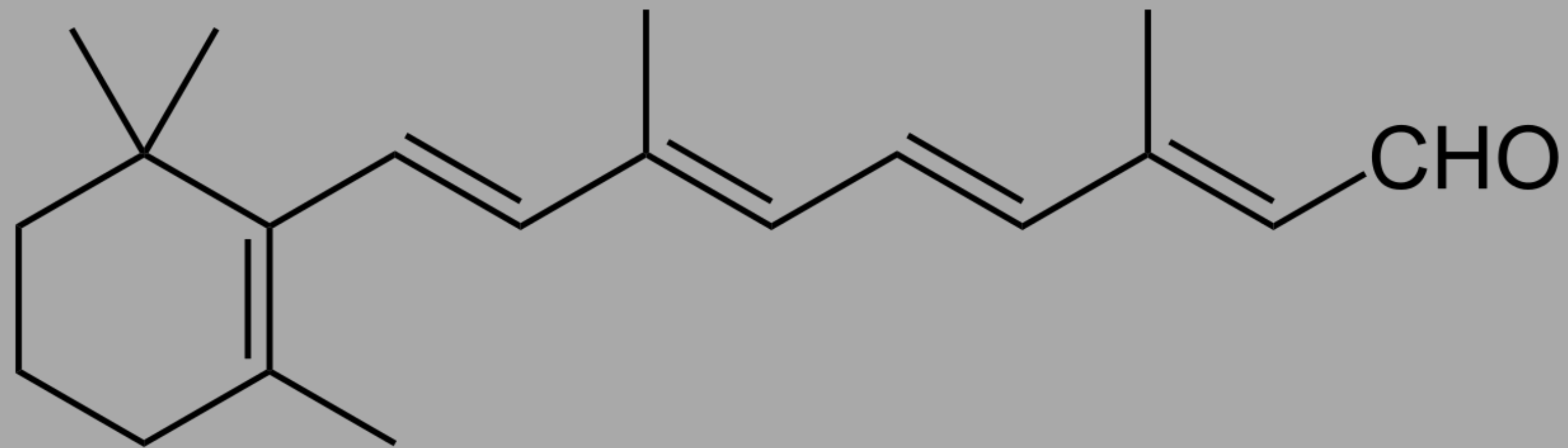


Thymine **T**



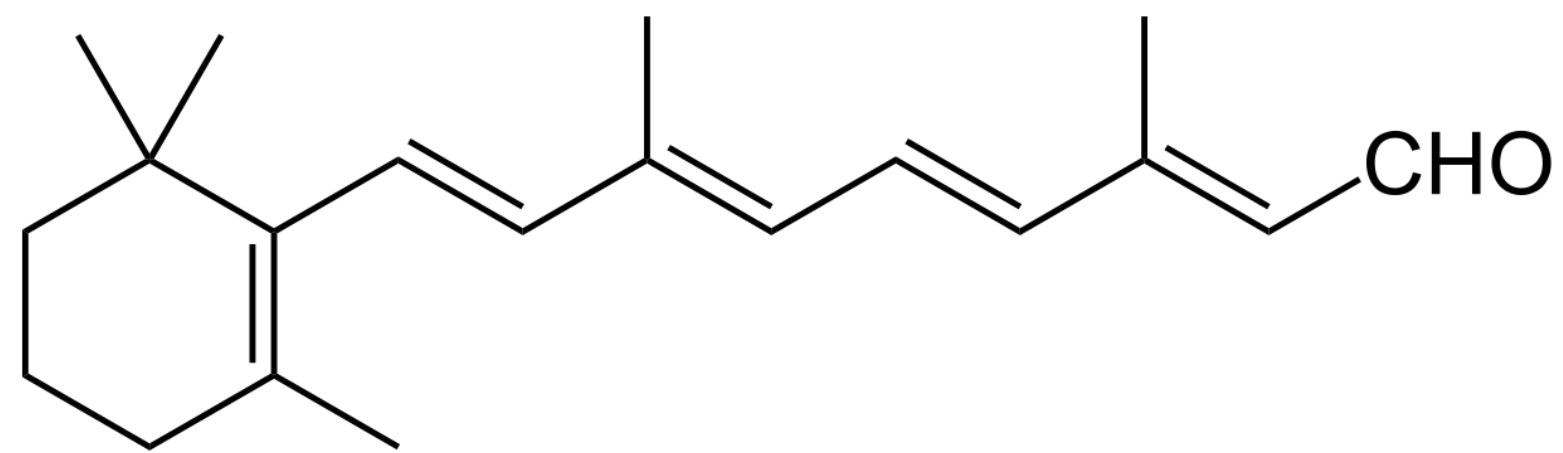
Nucleobases of DNA

Lipids take on a variety of forms

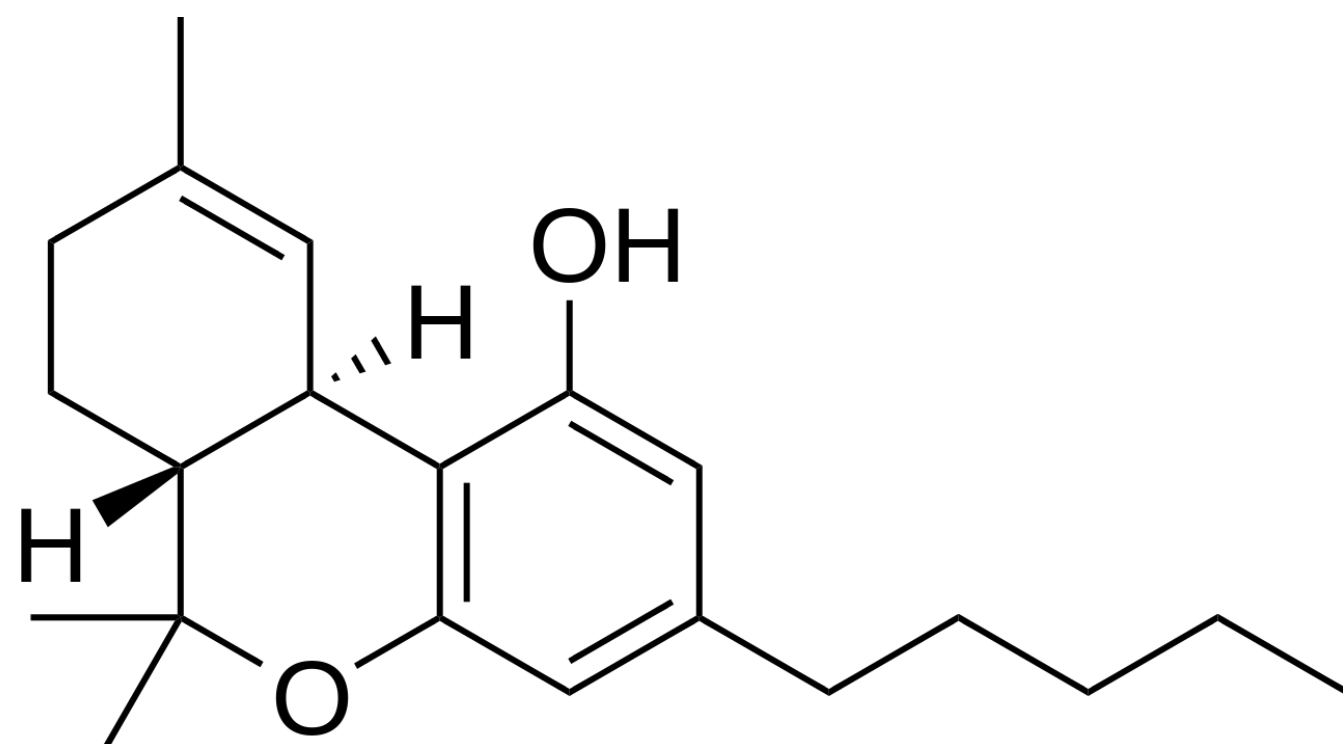


trans-Retinal

Lipids take on a variety of forms



trans-Retinal

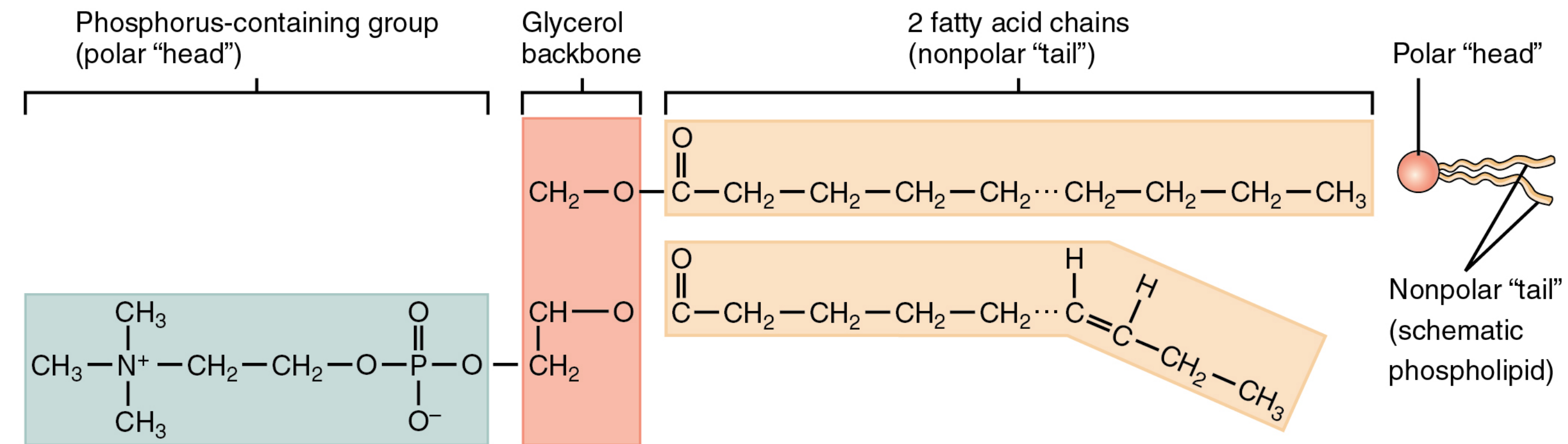


tetrahydrocannabinol

(a) Phospholipids

Two fatty acid chains and a phosphorus-containing group are attached to the glycerol backbone.

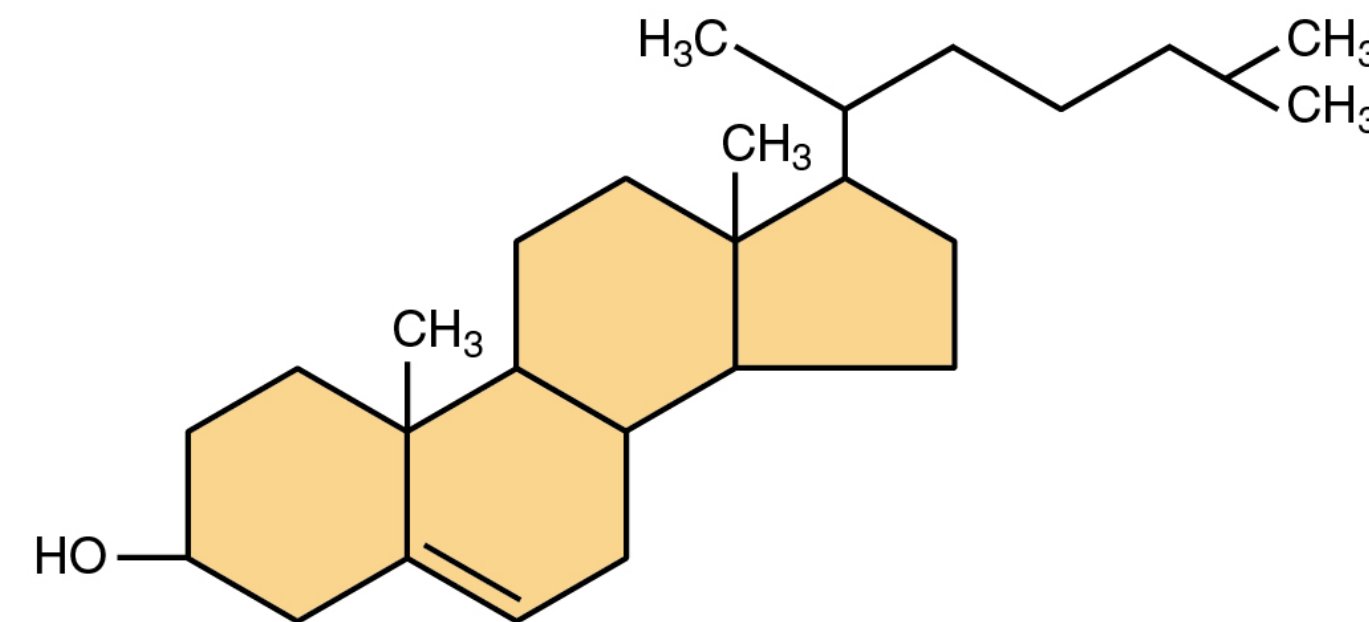
Example: Phosphatidylcholine



(b) Sterols

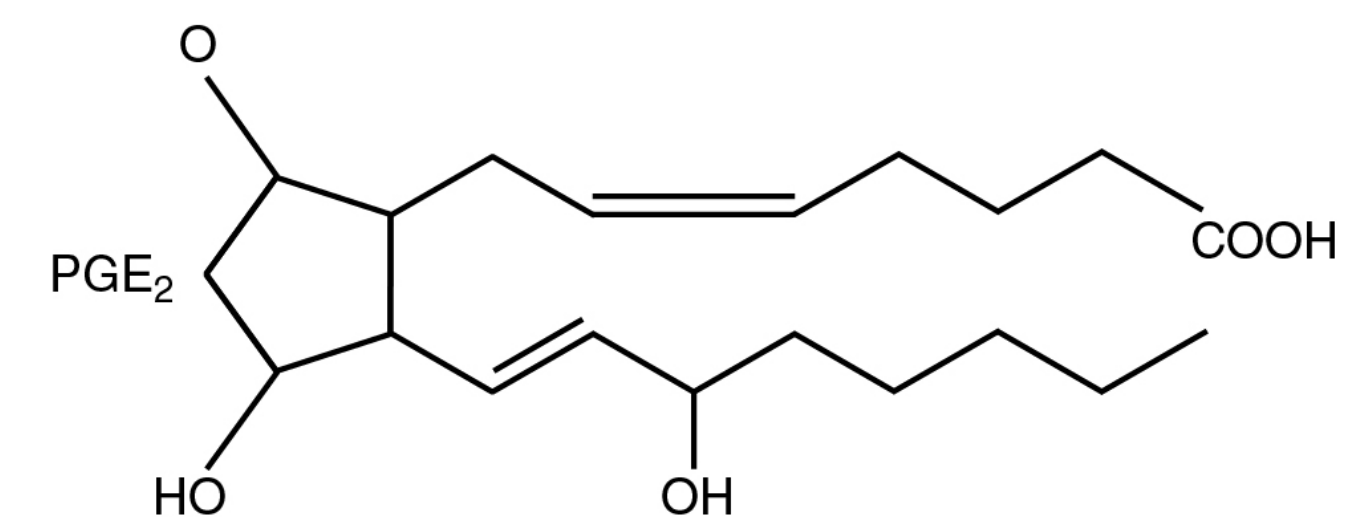
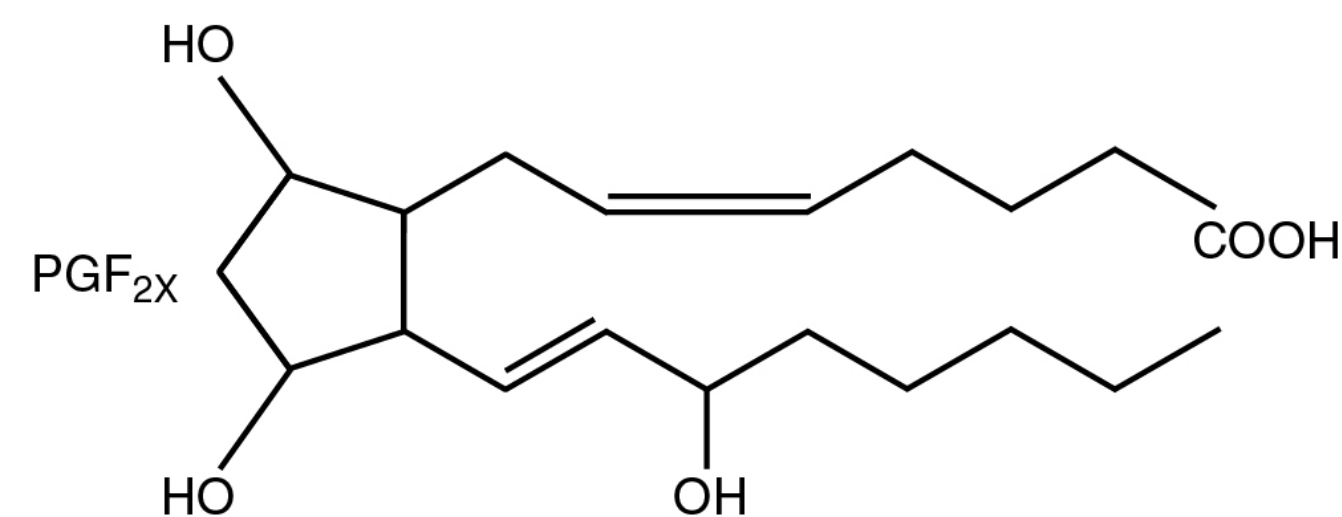
Four interlocking hydrocarbon rings from a steroid.

Example: Cholesterol (cholesterol is the basis for all steroids formed in the body)



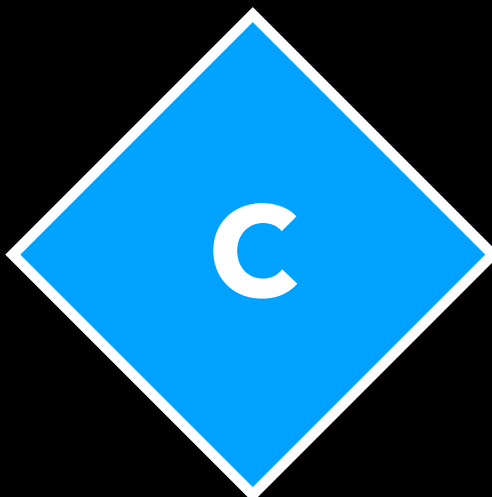
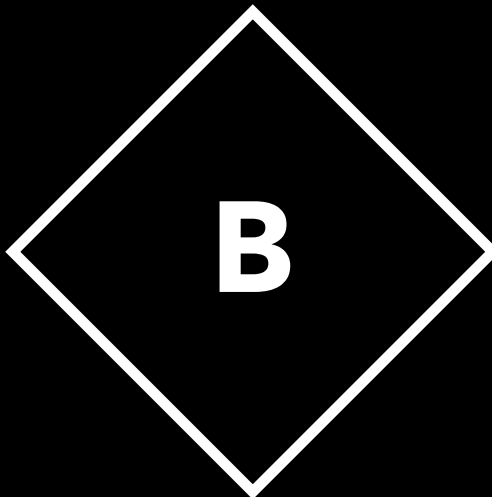
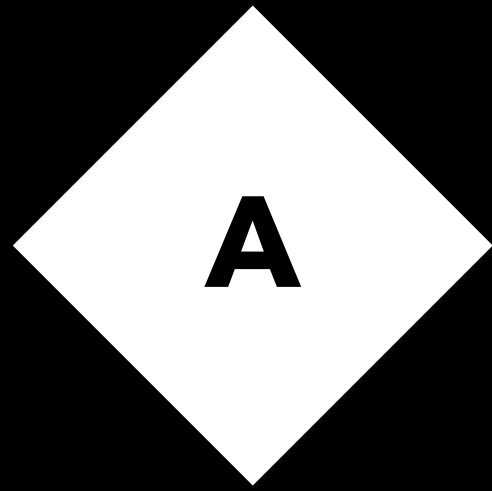
From: Wikimedia Commons (https://commons.wikimedia.org/wiki/File:222_Other_Important_Lipids-01.jpg)

(c) Prostaglandins

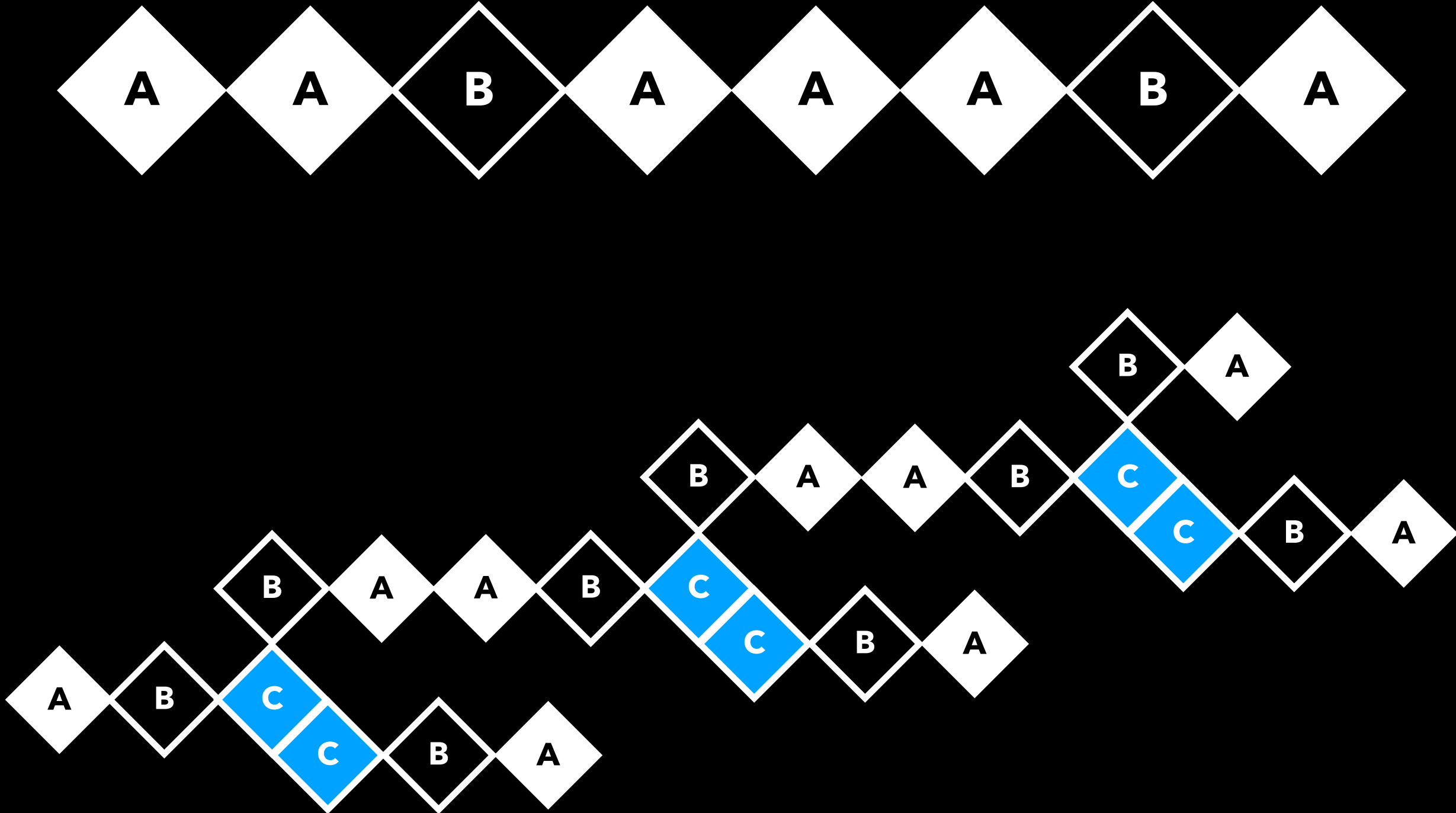


Biopolymers are
programmable materials

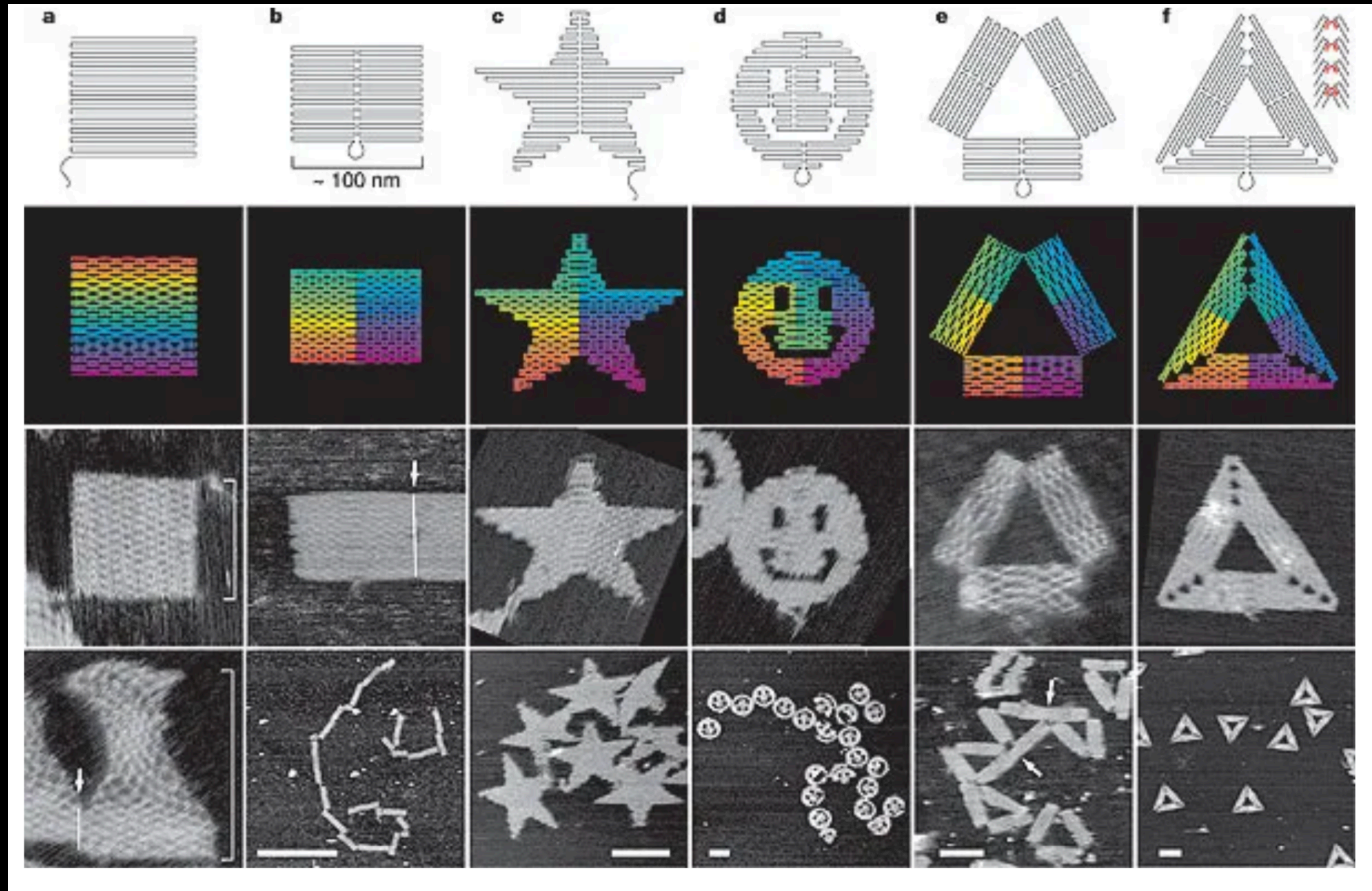
monomers



polymers



programmable materials: e.g., DNA origami

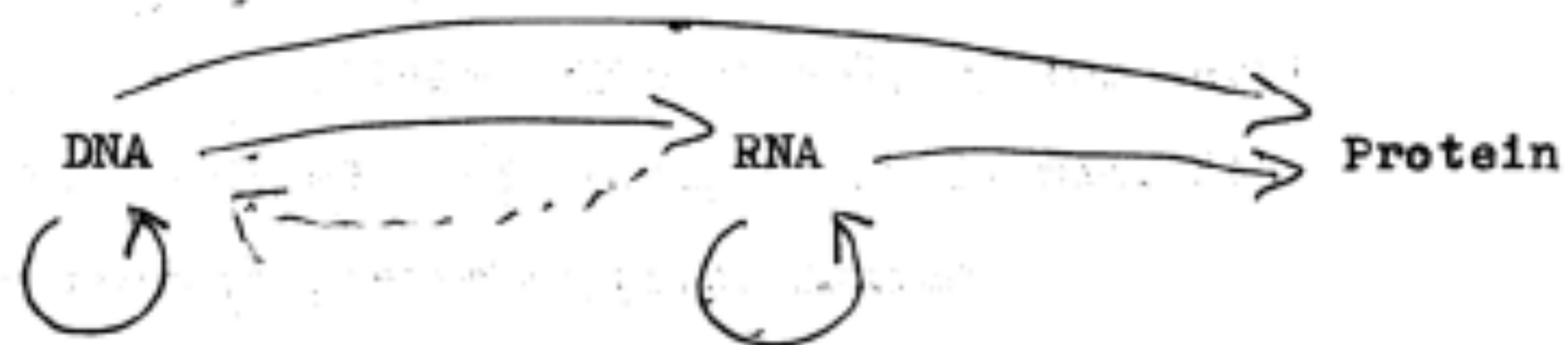


Ideas on Protein Synthesis (Oct. 1956)

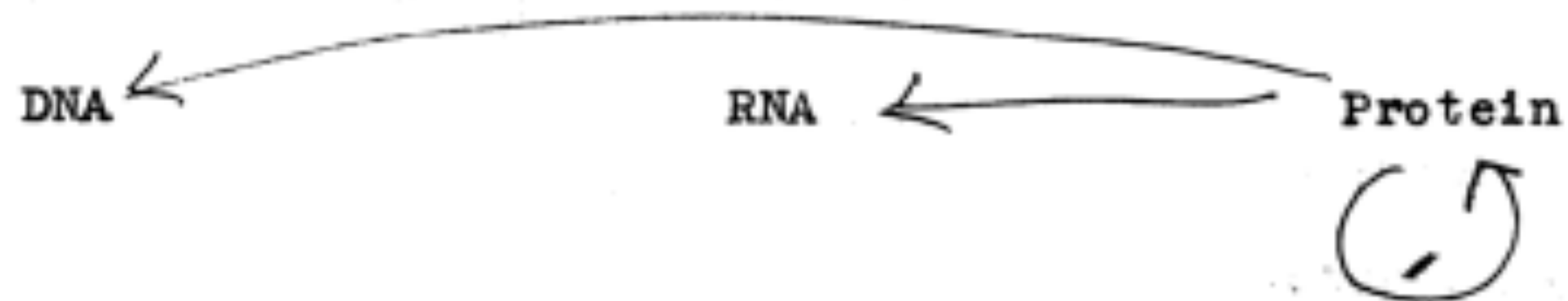
The Doctrine of the Triad.

The Central Dogma: "Once information has got into a protein it can't get out again". Information here means the sequence of the amino acid residues, or other sequences related to it.

That is, we may be able to have

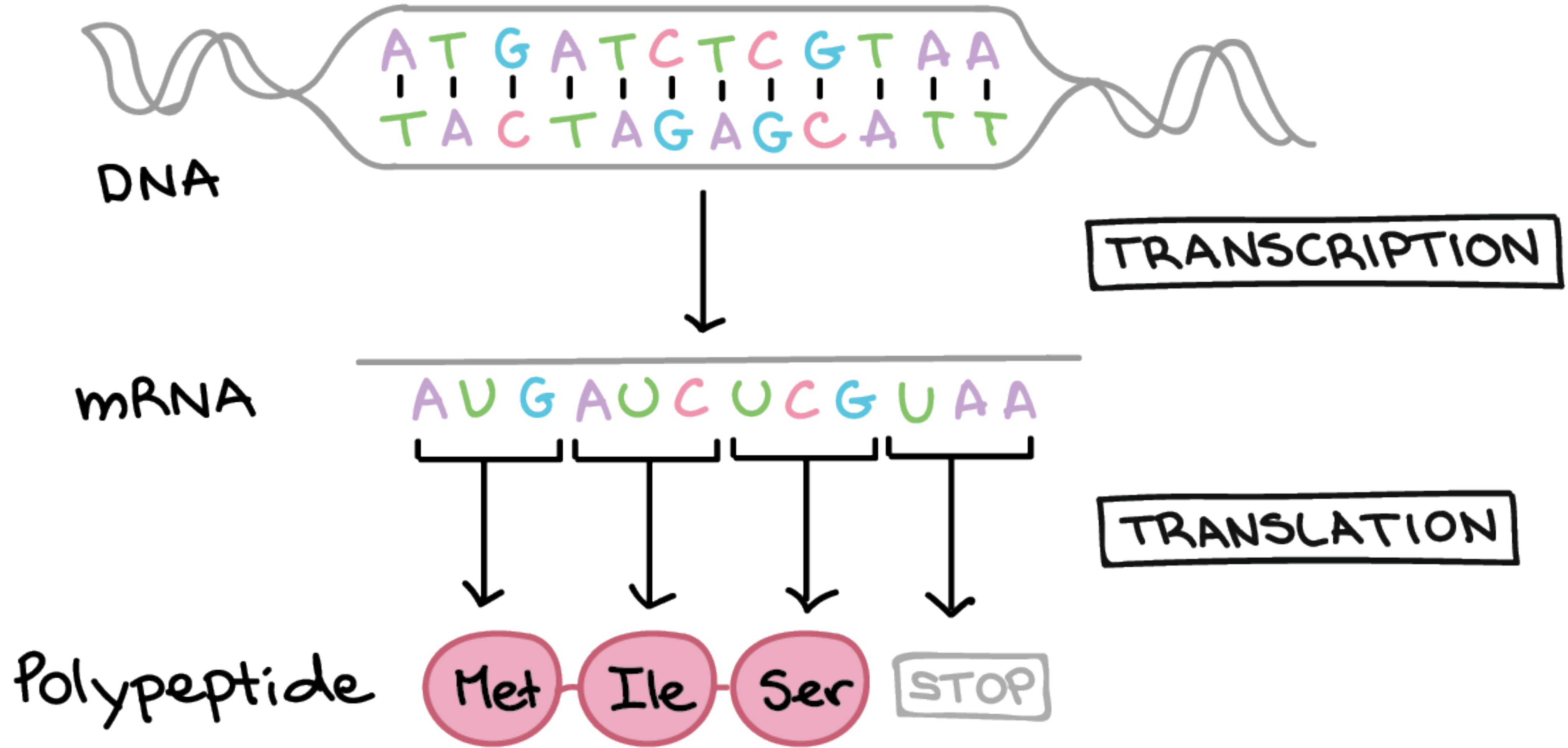


but never



where the arrows show the transfer of information.

THE CENTRAL DOGMA

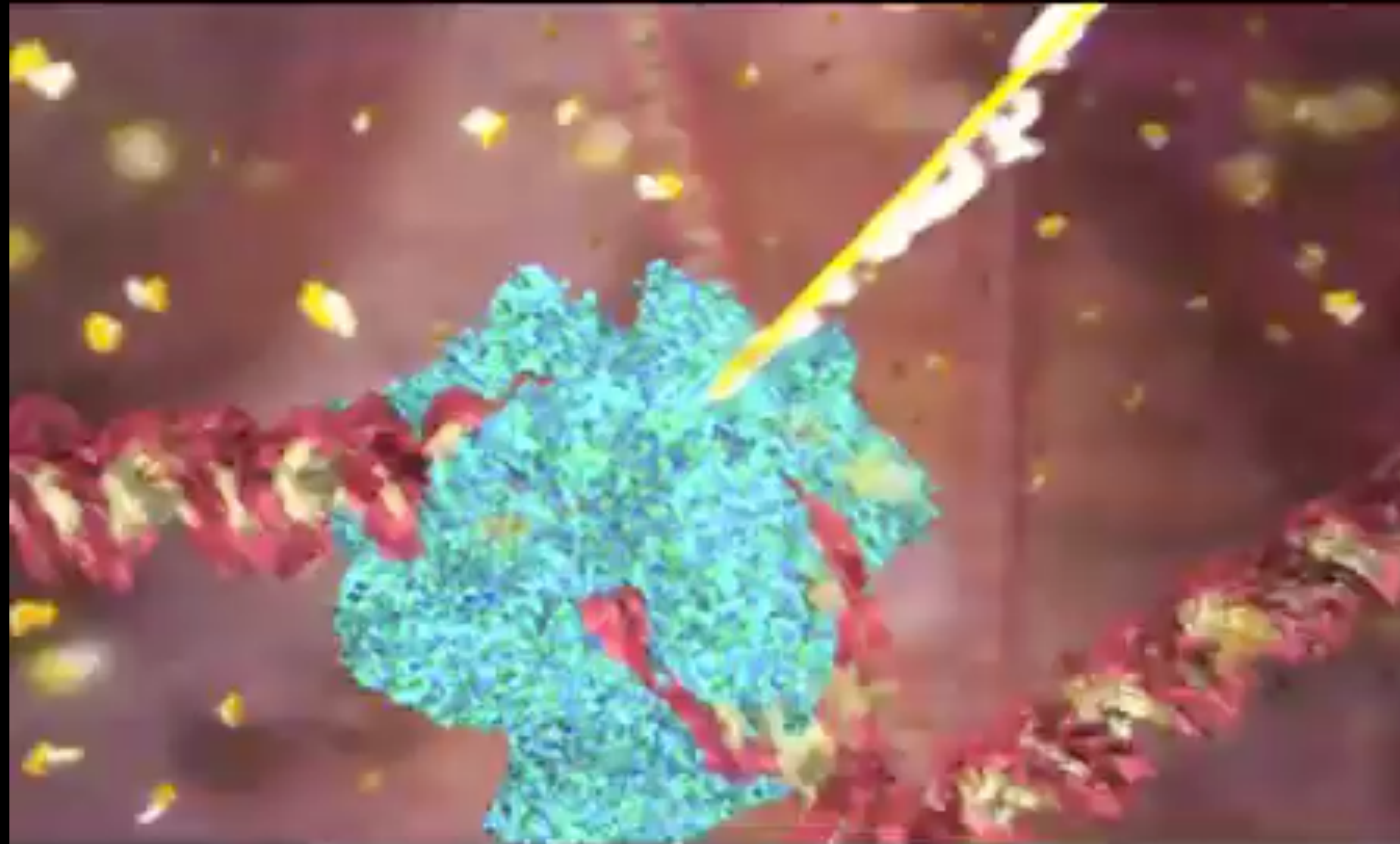


How does *information*
get converted from DNA to proteins?

How do *atoms*
get converted from DNA to proteins?

Atoms: RNA polymerase reads DNA, writes RNA

wehi.edu.au



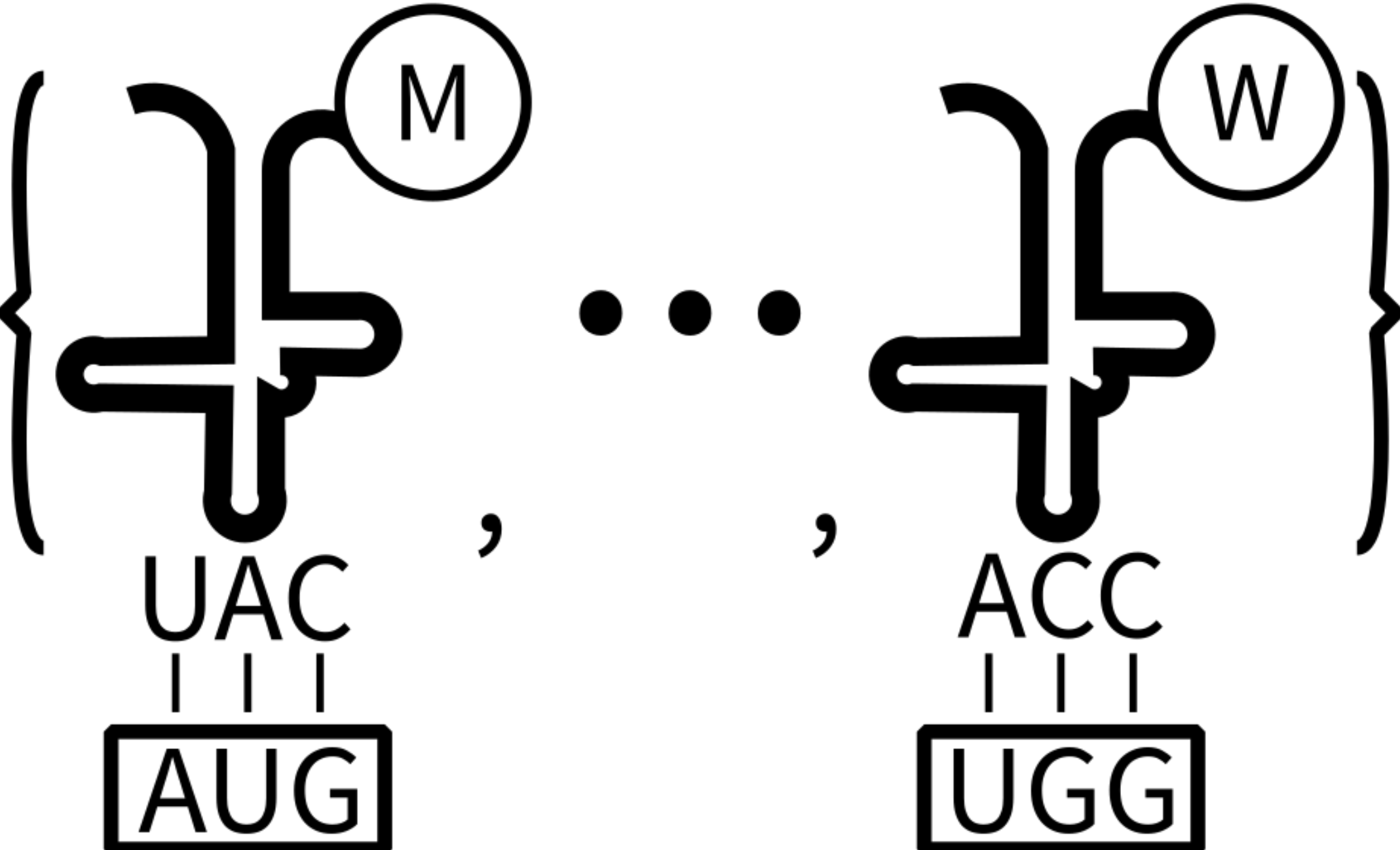
Transcription of a gene

Atoms: the Ribosome reads RNA, writes protein

wehi.edu.au



Information: the Genetic Code maps RNA to Protein



Second Position

		U	C	A	G	
First Position	U	UUU : F	UCU : S	UAU : Y	UGU : C	U
		UUC : F	UCC : S	UAC : Y	UGC : C	C
		UUA : L	UCA : S	UAA : *	UGA : *	A
		UUG : L	UCG : S	UAG : *	UGG : W	G
	C	CUU : L	CCU : P	CAU : H	CGU : R	U
		CUC : L	CCC : P	CAC : H	CGC : R	C
		CUA : L	CCA : P	CAA : Q	CGA : R	A
		CUG : L	CCG : P	CAG : Q	CGG : R	G
	A	AUU : I	ACU : T	AAU : N	AGU : S	U
		AUC : I	ACC : T	AAC : N	AGC : S	C
		AUA : I	ACA : T	AAA : K	AGA : R	A
		AUG : M	ACG : T	AAG : K	AGG : R	G
	G	GUU : V	GCU : A	GAU : D	GGU : G	U
		GUC : V	GCC : A	GAC : D	GGC : G	C
		GUA : V	GCA : A	GAA : E	GGA : G	A
		GUG : V	GCG : A	GAG : E	GGG : G	G
						Third Position

Information: the Genetic Code maps RNA to Protein

mRNA



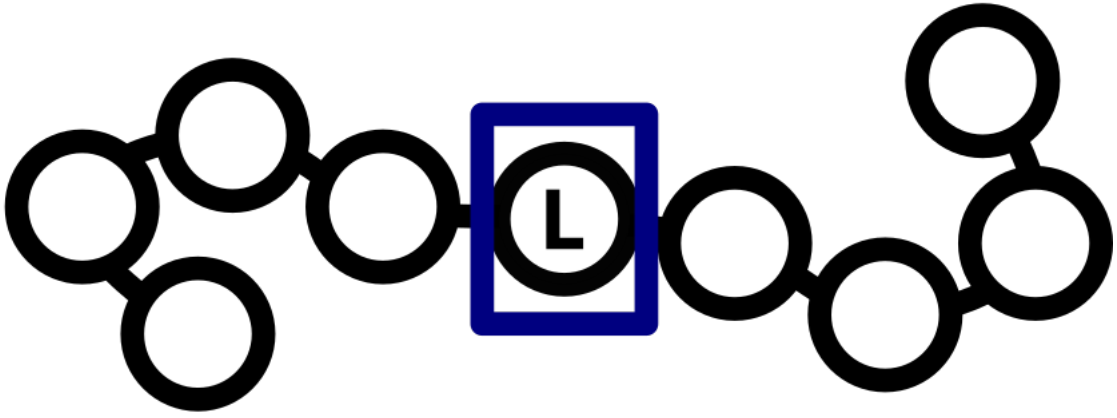
Protein

UUA



		Second Position				
		U	C	A	G	
First Position	C	UUU:F	UCU:S	UAU:Y	UGU:C	U
		UUC:F	UCC:S	UAC:Y	UGC:C	C
		UUA:L	UCA:S	UAA:*	UGA:*	A
		UUG:F	UCG:S	UAG:*	UGG:W	G
A	C	CUU:L	CCU:P	CAU:H	CGU:R	U
		CUC:L	CCC:P	CAC:H	CGC:R	C
		CUA:L	CCA:P	CAA:Q	CGA:R	A
		CUG:L	CCG:P	CAG:Q	CGG:R	G
G	A	AUU:I	ACU:T	AAU:N	AGU:S	U
		AUC:I	ACC:T	AAC:N	AGC:S	C
		AUA:I	ACA:T	AAA:K	AGA:R	A
		AUG:M	ACG:T	AAG:K	AGG:R	G
G	G	GUU:V	GCU:A	GAU:D	GGU:G	U
		GUC:V	GCC:A	GAC:D	GGC:G	C
		GUA:V	GCA:A	GAA:E	GGA:G	A
		GUG:V	GCG:A	GAG:E	GGG:G	G

Leucine



Some awesome links for extra info

[XBio](#) (e-book)

[Cell Biology by the Numbers](#) (e-book)

[Protein Data Bank](#) (web page)

[Khan Academy - Biomolecules](#) (videos)

[Khan Academy - Central Dogma](#) (videos)