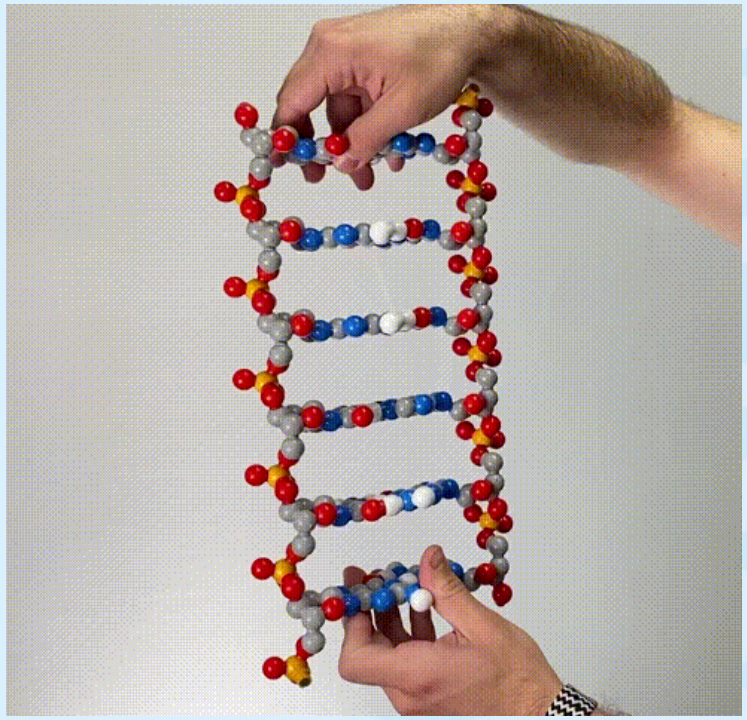
3d molecular designs

Transforming Science Learning

Dynamic DNA

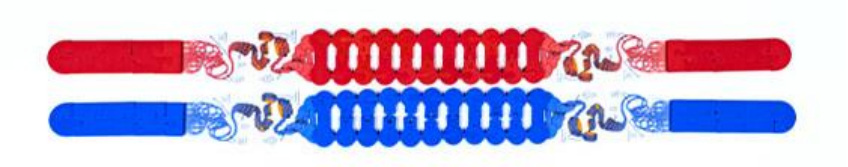
…more than a just a bunch of A’s, T’s, G’s and C’s



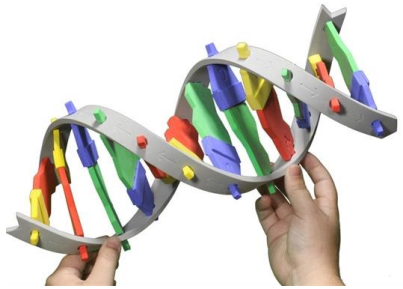
Tim Herman

DNA… *what do you teach?*

Genetics

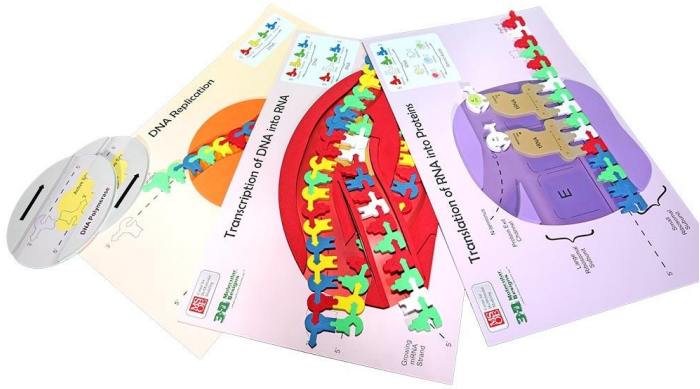


DNA Structure



The Central Dogma

DNA → RNA → Protein



More DNA-related topics you could teach:

Bioinformatics…. *Gene Maps (Paper Bio-informatics),*

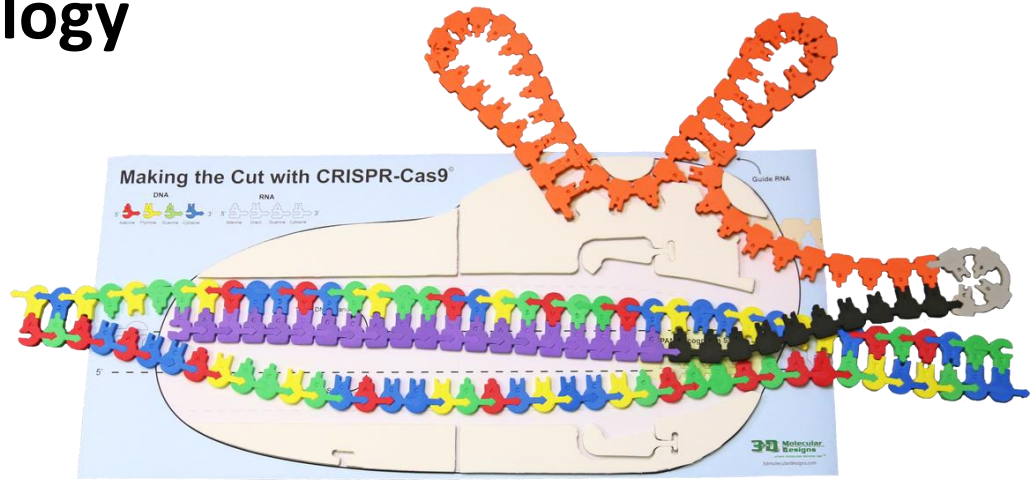
Data Science, AI and Alpha-Fold

Biotechnology

Recombinant DNA Technology

Sanger DNA Sequencing

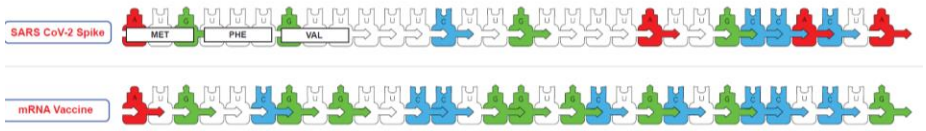
PCR



CRISPR-based Genome Editing

Epi-genetics… *chemical modifications of both histones and DNA*

mRNA Vaccines and Pseudouridine



Sign-Up for a 3DMD Summer Course

Modeling the Molecular World

Fee-based

Session 1: July 29 – August 2

Session 2: August 5 – August 9

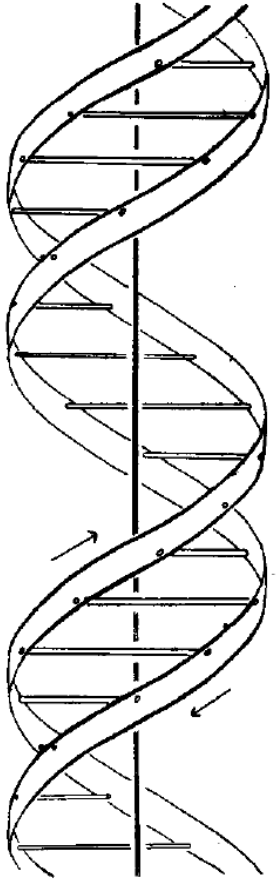
Modeling Infection & Immunity

Grant supported

June 24–28, 2024

Watson and Crick,….. in 1953

1



It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material

2

***Whether a special enzyme is required to carry out the polymerization**, or whether the single helical chain already formed acts effectively as an enzyme, remains to be seen.*

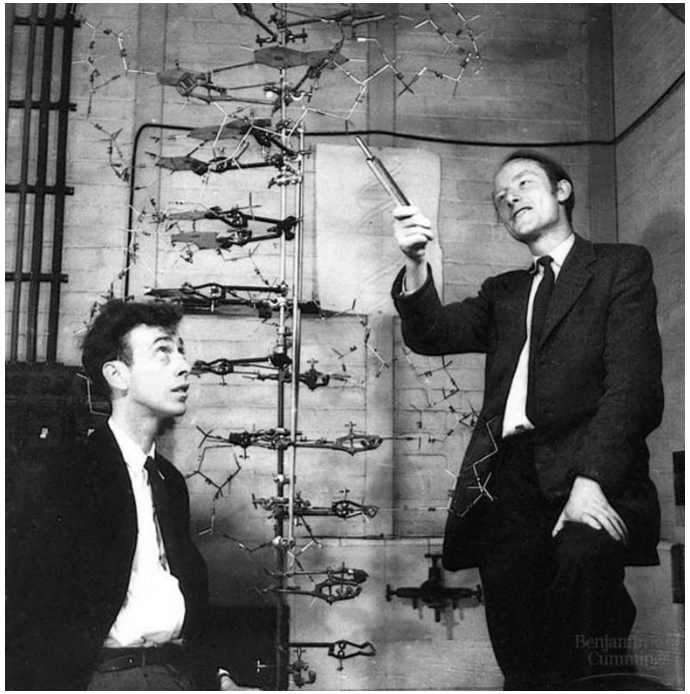
Since the two chains in our model are intertwined, it is essential for them to untwist if they are to separate: As they make one complete turn around each other in 34. A., there will be about 150 turns per million molecular weight, so that whatever the precise structure of the chromosome a considerable amount of uncoiling would be necessary. ***It is well known from microscopic observation that much coiling and uncoiling occurs during mitosis, and though this is on a much larger scale it probably reflects similar processes on a molecular level.*** *Although it is difficult at the moment to see how these processes occur without everything getting tangled, we do not feel that this objection will be insuperable.*

Nature 171,964-967 1953 (May 30) **Genetical Implications of the Structure of Deoxyribonucleic Acid**

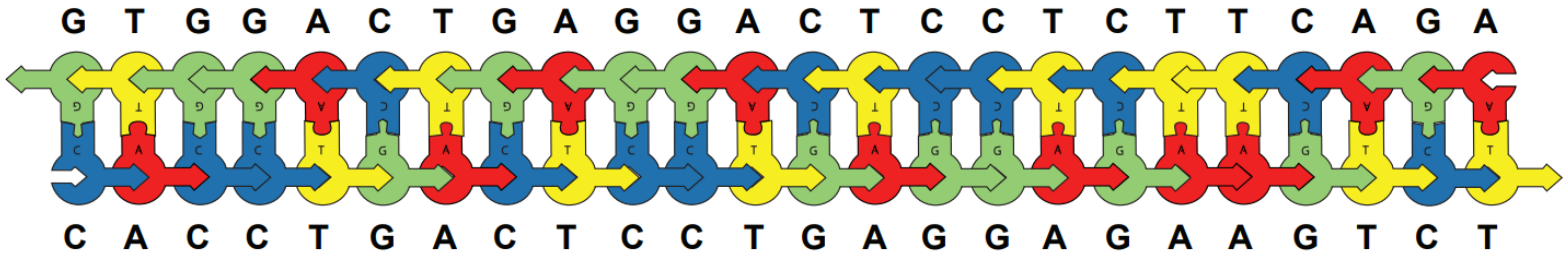
Nature 171, 737-738, 1953 (April 25) **Molecular Structure of Deoxypentose Nucleic Acids**

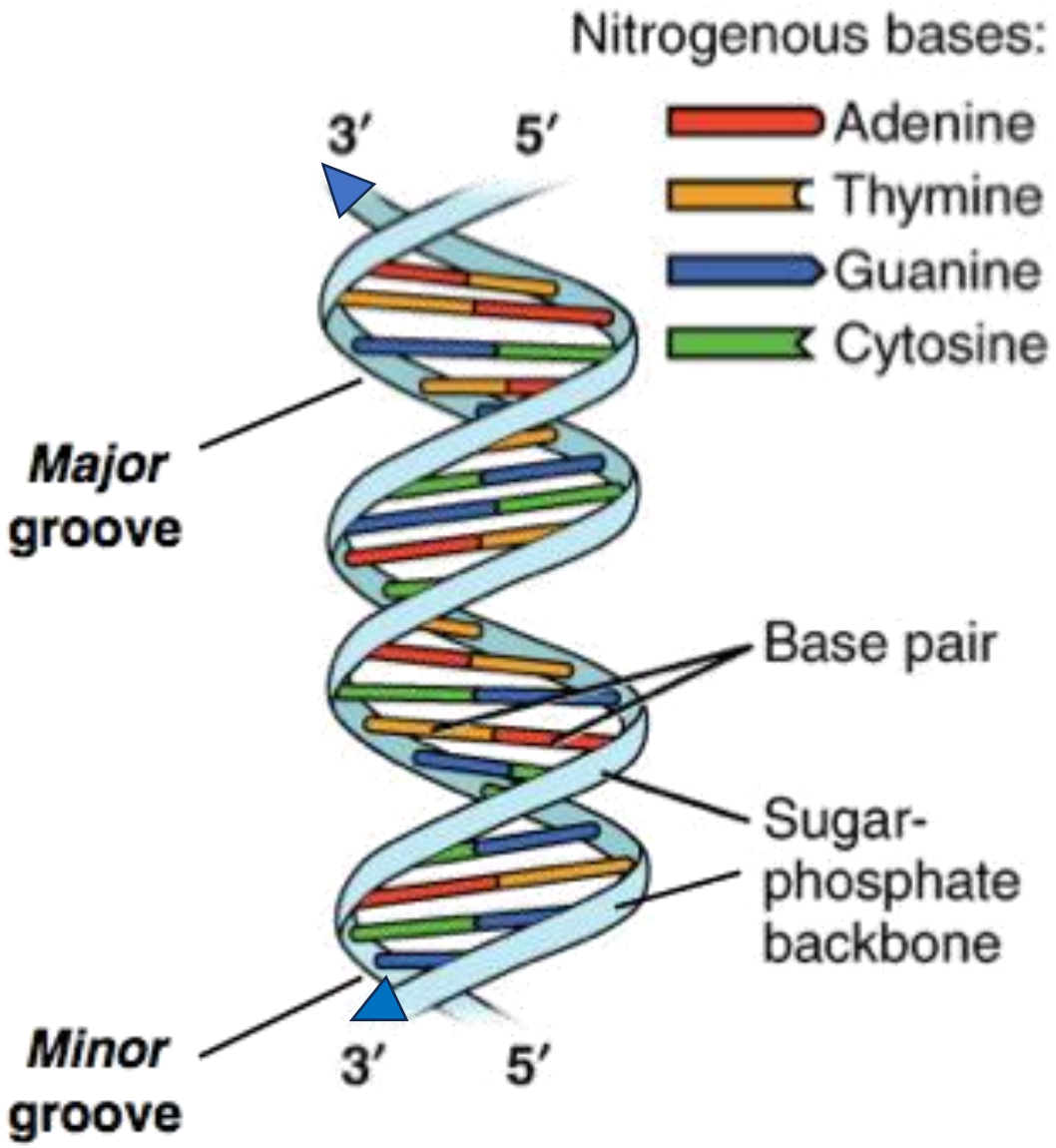
The MRC Laboratory of Molecular Biology

…. a Nobel fellow on every floor….

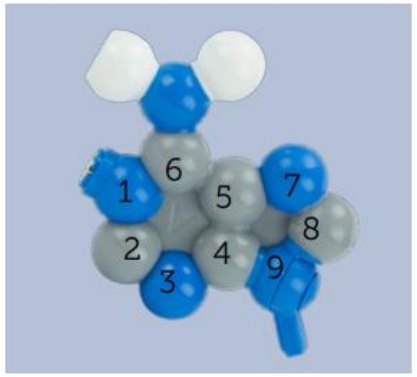


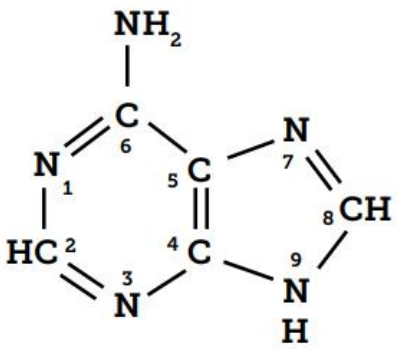
"We have discovered the secret of life."


G T G G A C T G A G G A C T C C T C T T C A G A
C A C C T G A C T C C T G A G G A G A A G T C T

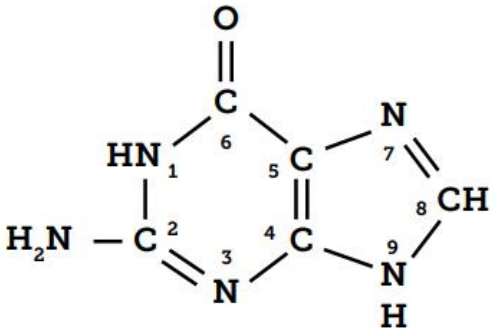

Nitrogenous bases:
Adenine
Thymine
Guanine
Cytosine
3′
5′
Major groove
Base pair
Sugar-phosphate backbone
Minor groove
3′
5′

Purines



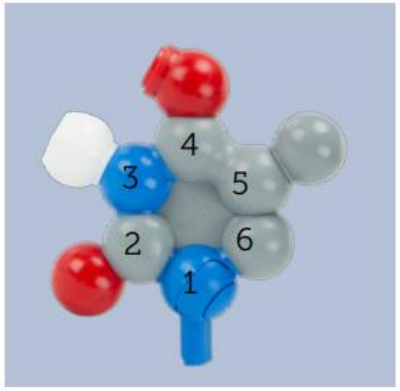


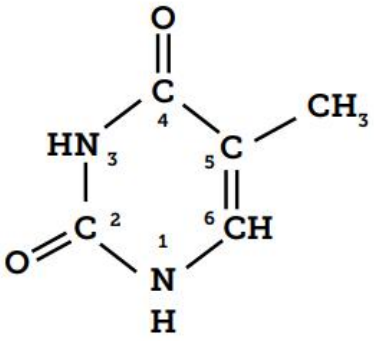
adenine (A)



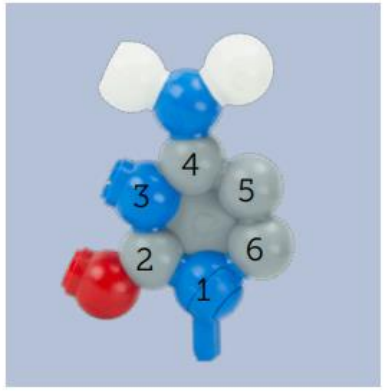
guanine (G)

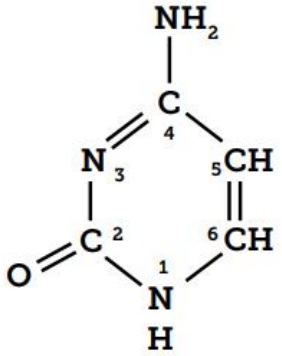
Pyrimidines



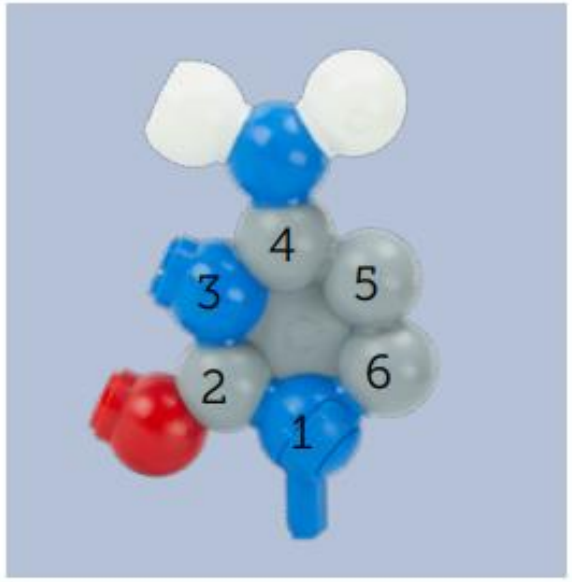


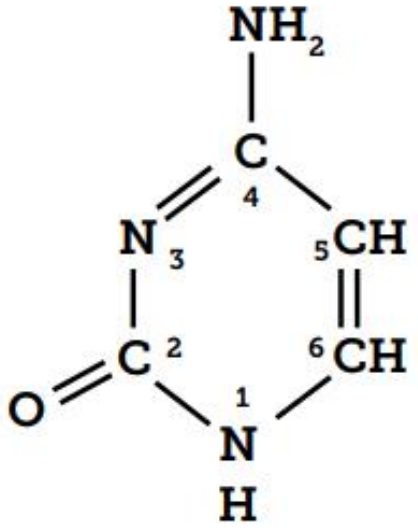
thymine (T)



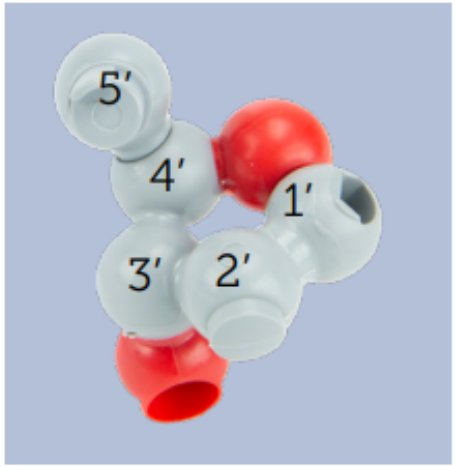


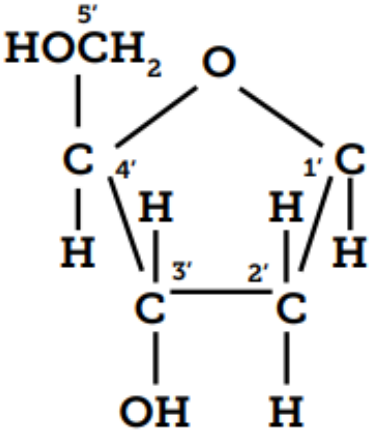
cytosine (C)





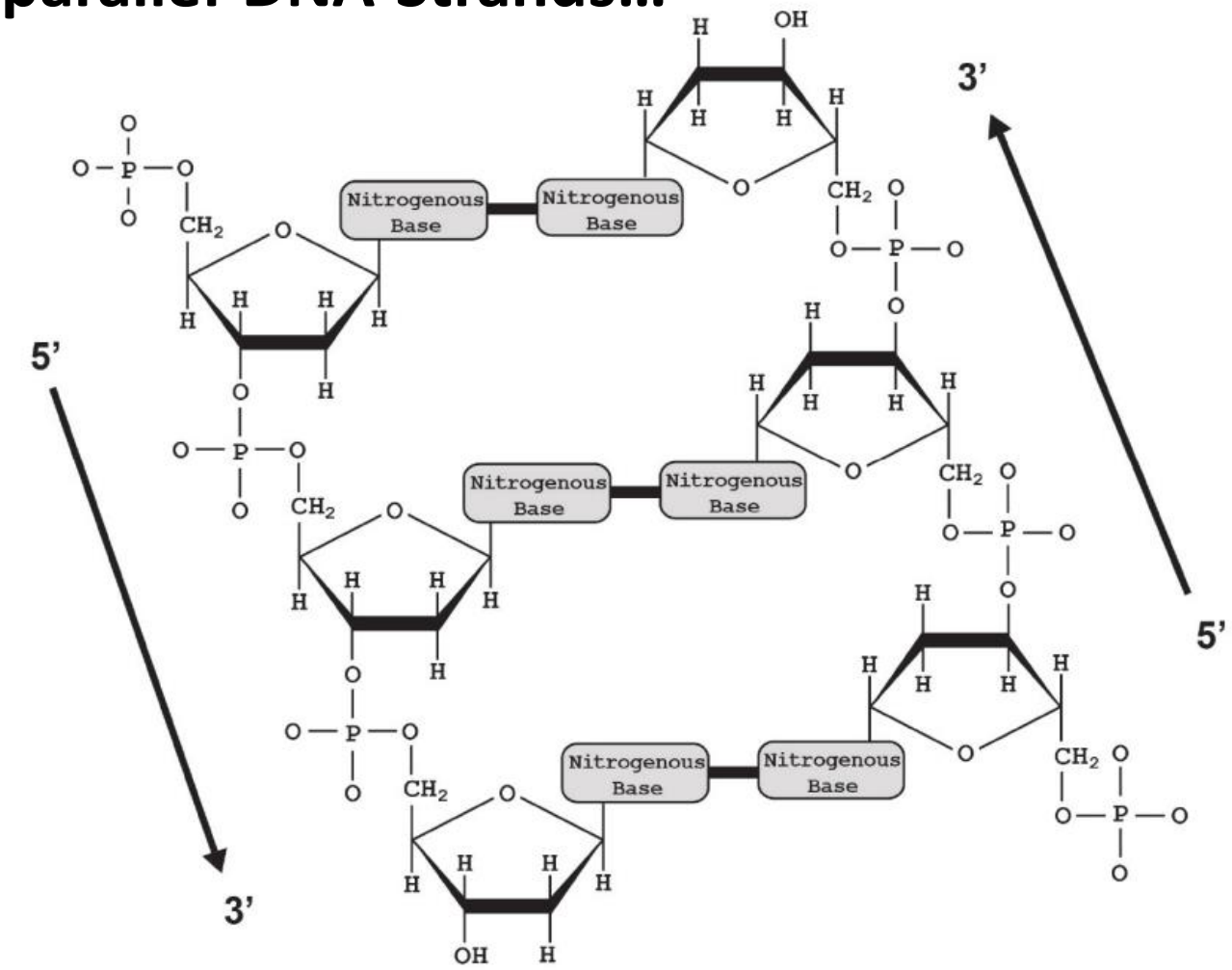
cytosine (C)

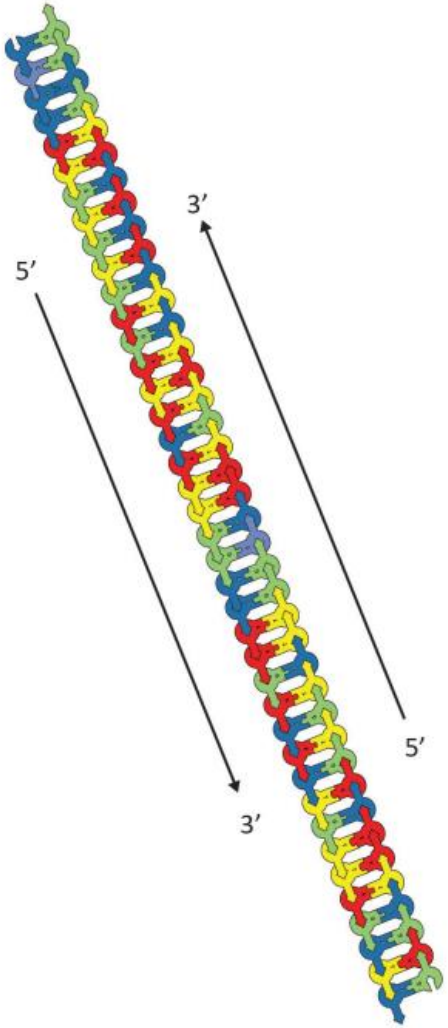


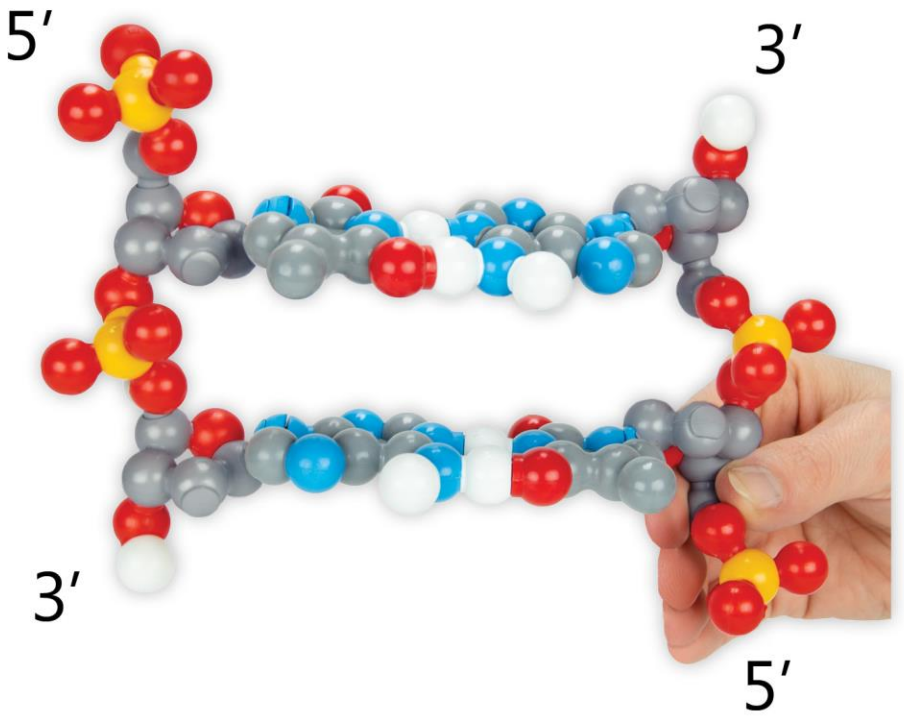


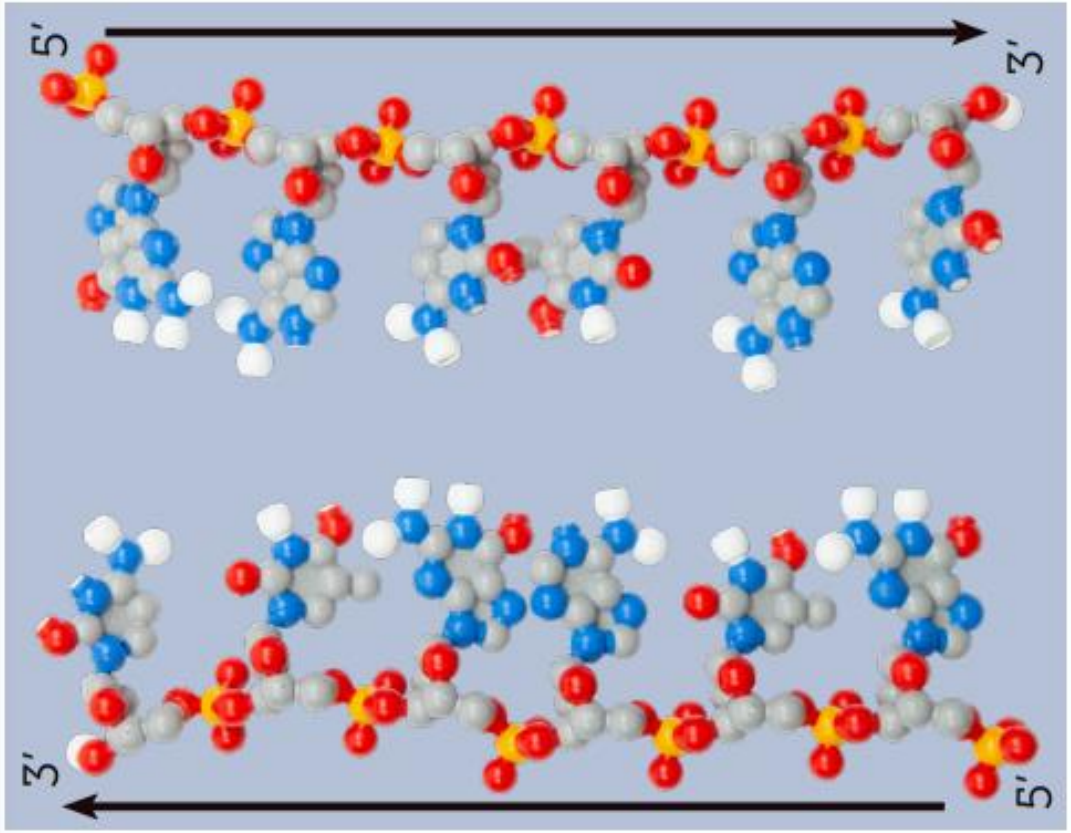
deoxyribose

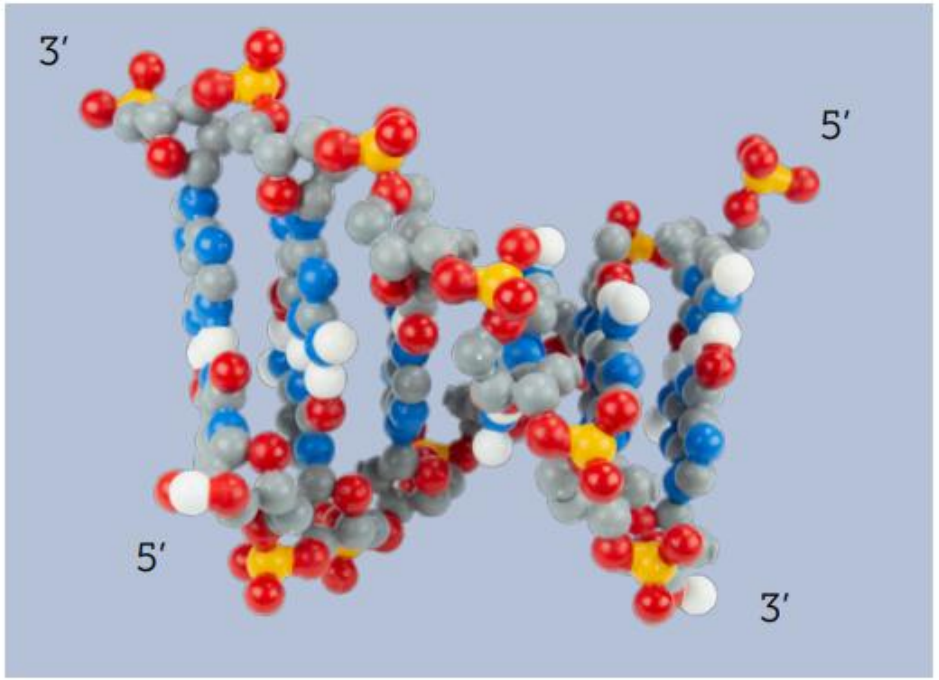
Anti-parallel DNA Strands…






5′
3′
3′
5′


5′
3′
3′
5′


3′
5′
5′
3′

And now,…. EPIGENETICS

In epigenetics, both histones and DNA
are chemically modified…
…to regulate gene expression.

Cytosine (C) is methylated…
only if it is followed by Guanosine

5’…..CpG…..3’

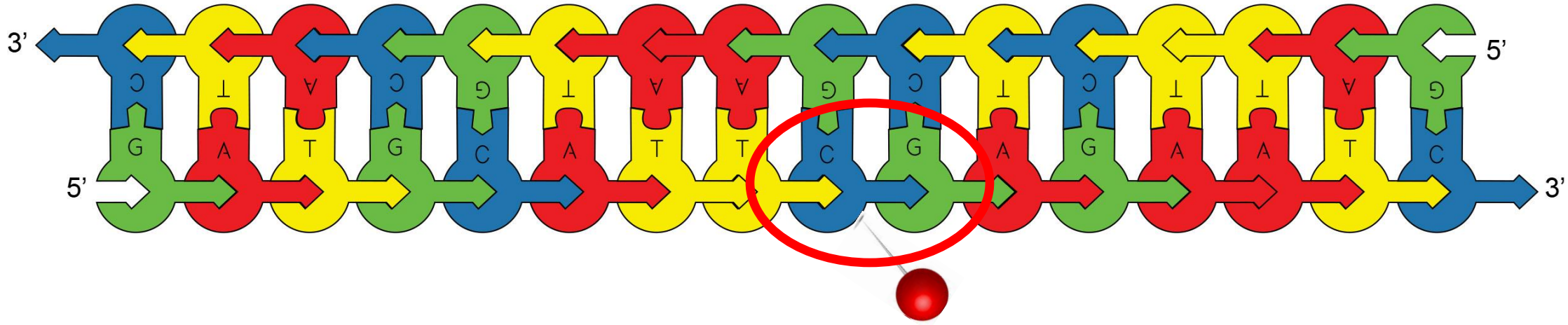
Let's go beyond teaching the WHAT….
… and start and start teaching the…

HOW? *There are enzymes called methylases*

WHEN? *Sometimes,…. Life is complicated*

WHY? *To impact the binding of transcription factors and to regulate gene expression*

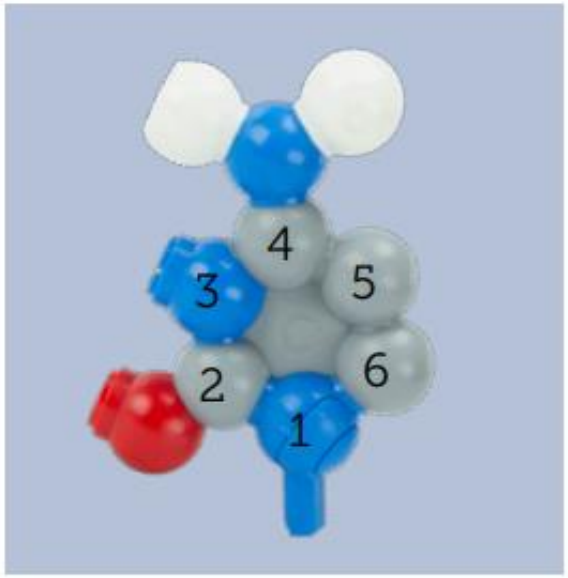
Find a 5'…CpG…3' -- and stick a pin in the C

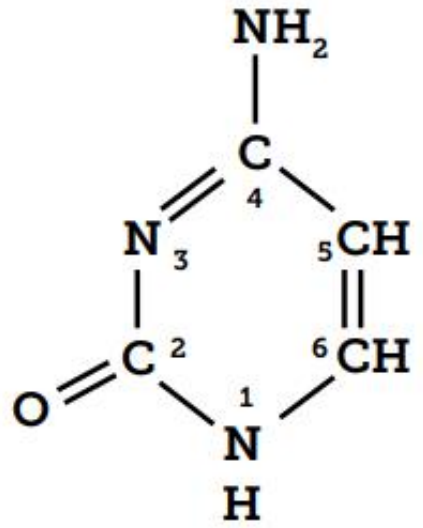


Then find a 5'…CpG…3' in your Dynamic DNA model

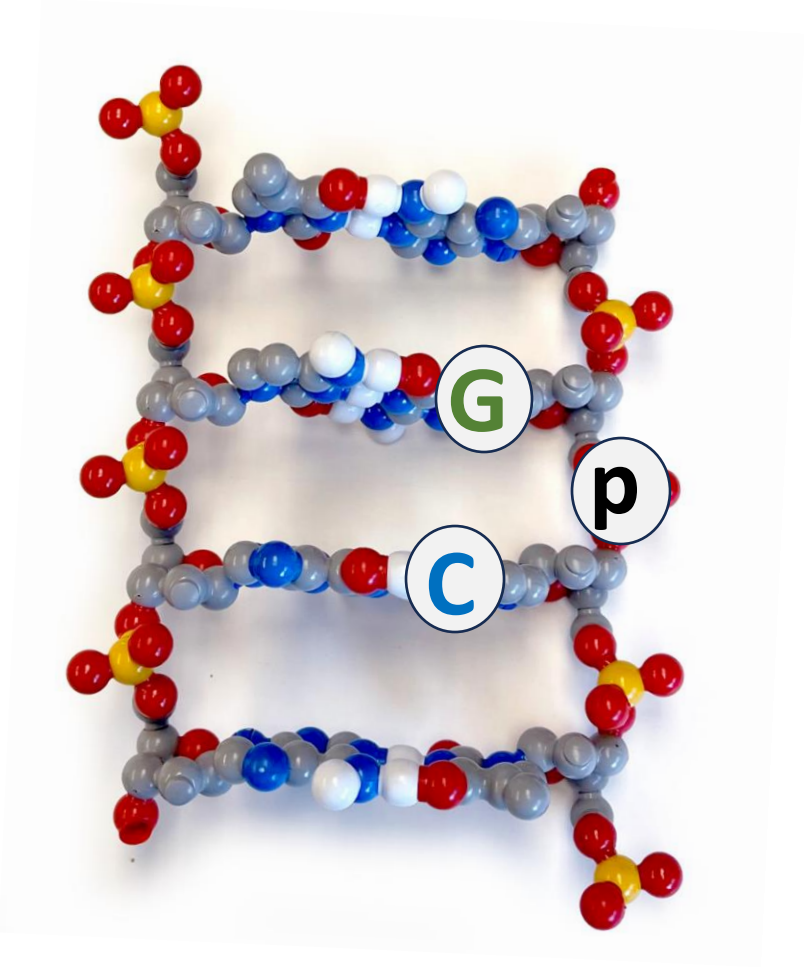
In epigenetics, the #5 carbon is methylated.

Find a CpG in your Dynamic DNA … and put a methyl group (sparkly hat) on the #5 carbon.

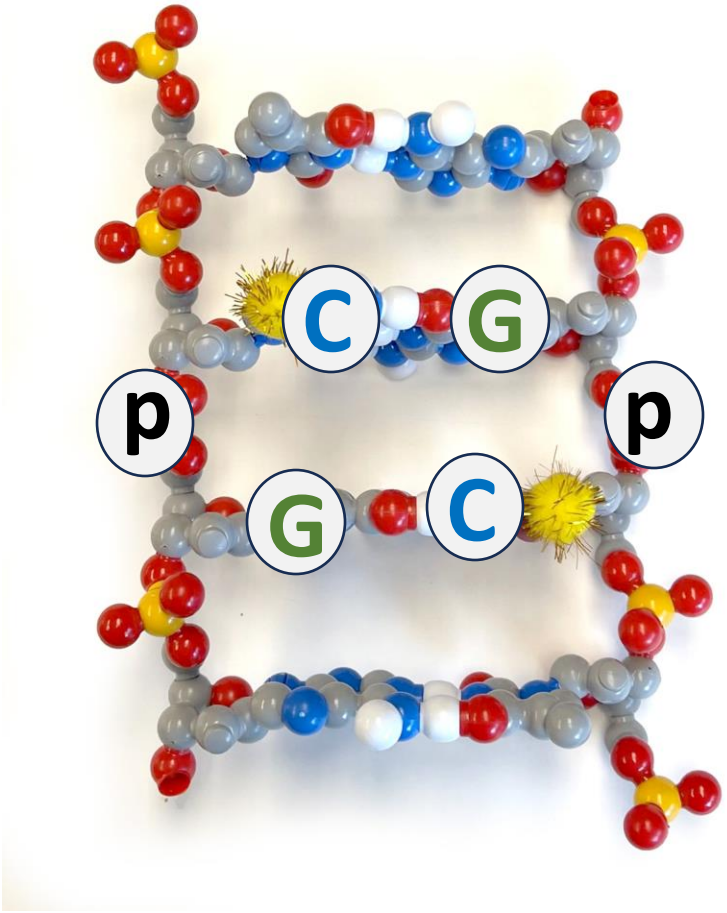




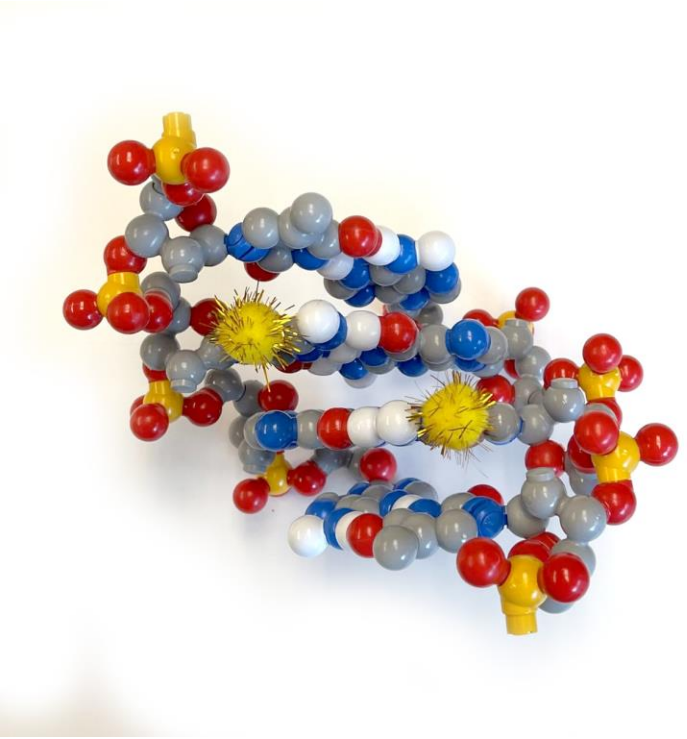
cytosine (C)



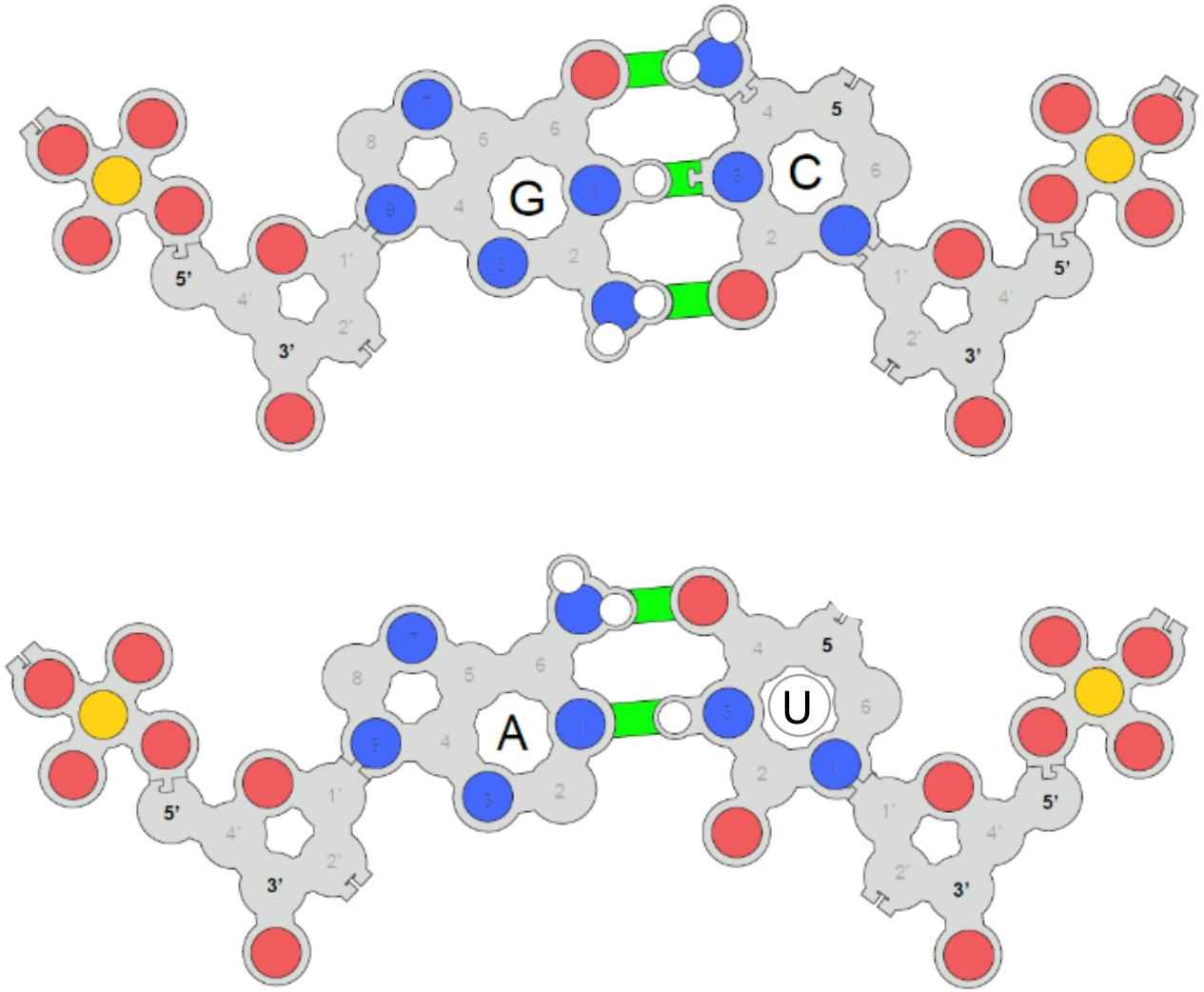
Whenever you find 1 CpG…



…you will find a second CpG in the opposite strand



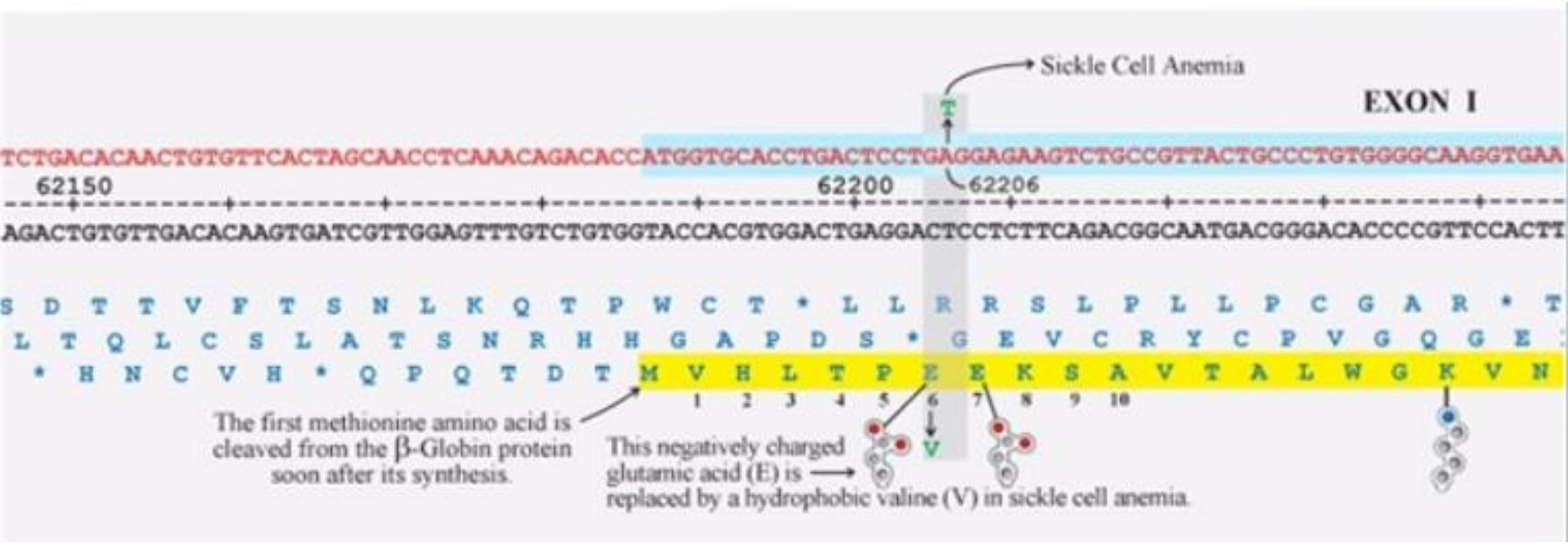
…and both methyl groups will end up in the major groove

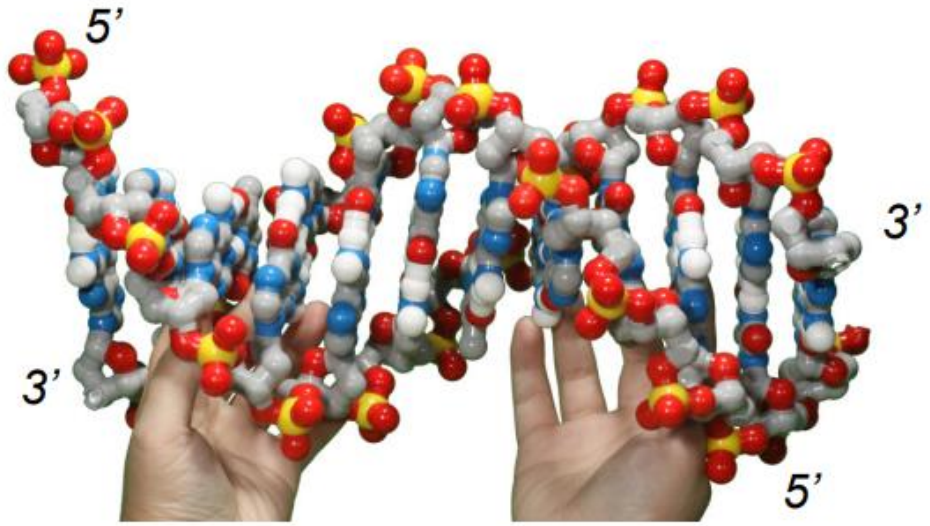

G
C
A
U
5'
3'

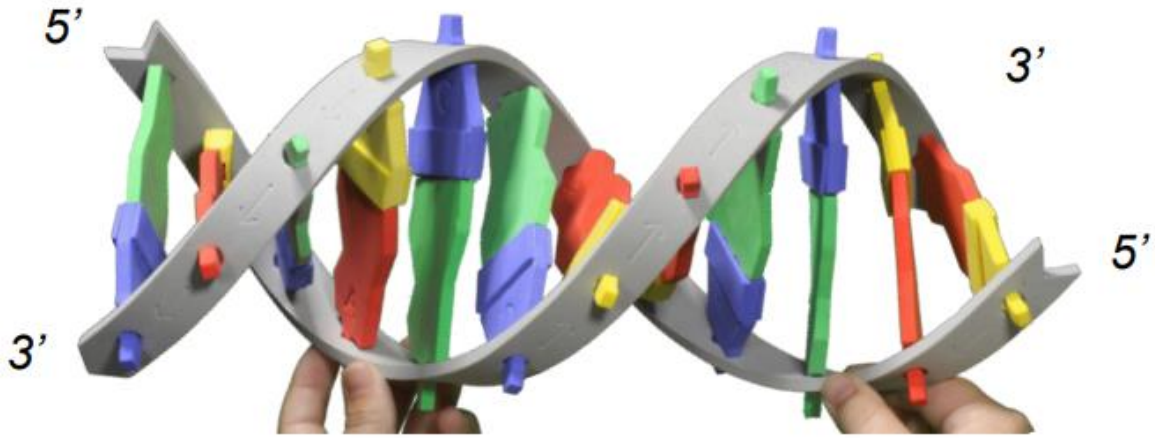
Where have all the CpG's gone? … *long time passing*.

You would expect to find a CpG dinucleotide every 16 basepairs of random sequence

You actually find only 1 CpG dinucleotide every 100 base pairs in the human genome.


Sickle Cell Anemia
EXON 1
TCTGACACAACTGTGTTCACTAGCAACCTCAAACAGACACCATGGTGCACCTGACTCCTGAGGAGAAGTCTGCCGTTACTGCCCTGTGGGGCAAGGTGAA
62150
62200
62206
AGACTGTGTTGACACAAGTGATCGTTGGAGTTTGTCTGTGGTACCACGTGGACTGAGGACTCCTCTTCAGACGGCAATGACGGGACACCCCGTTCCACTT
S D T T V F T S N L K Q T P W C T * L L R R S L P L L P C G A R * T
L T Q L C S L A T S N R H H G A P D S * G E V C R Y C P V G Q G E
* H N C V H * Q P Q T D T M V H L T P E E K S A V T A L W G K V N
1 2 3 4 5 6 7 8 9 10
The first methionine amino acid is cleaved from the β-Globin protein soon after its synthesis.
This negatively charged glutamic acid (E) is replaced by a hydrophobic valine (V) in sickle cell anemia.


5’
3’
3’
5’


5’
3’
3’
5’

3d molecular designs

Transforming Science Learning