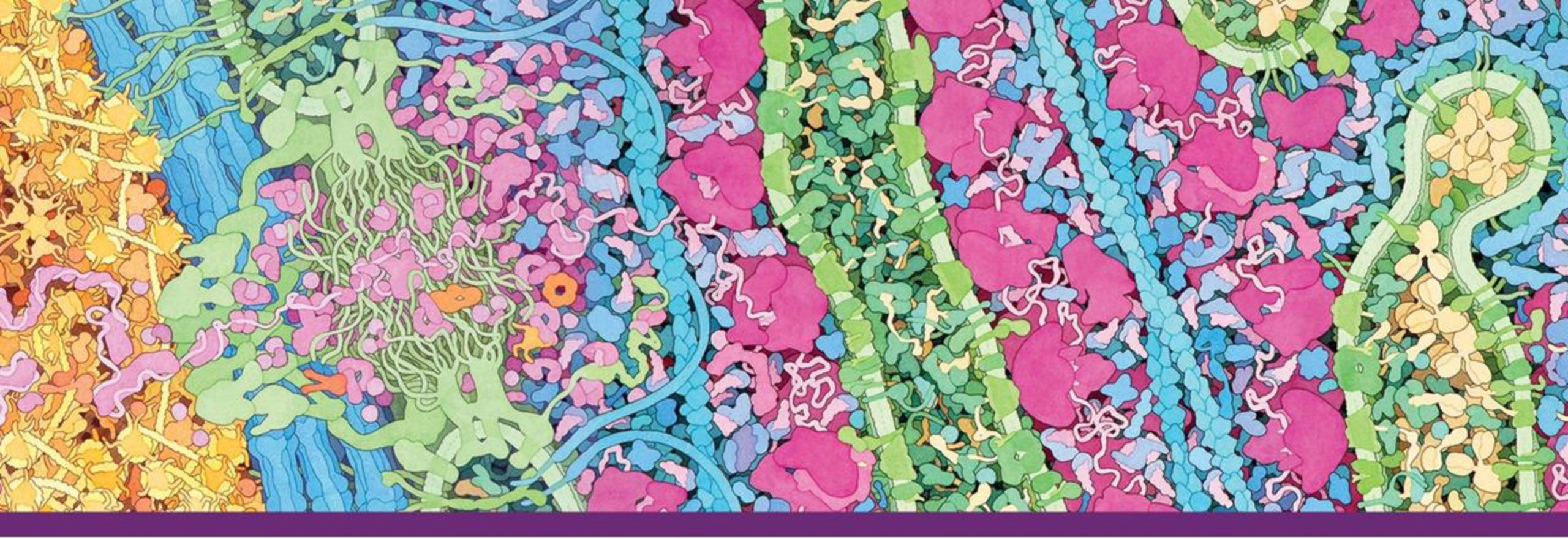


3d molecular designs

Transforming Science Learning

3d molecular designs
Transforming Science Learning

Unraveling Multiple Representations of Chromosomes to Reveal Student Thinking

Presenter: Chris Chou

Longmont High School (Longmont, CO)

Mrs.Chou@gmail.com

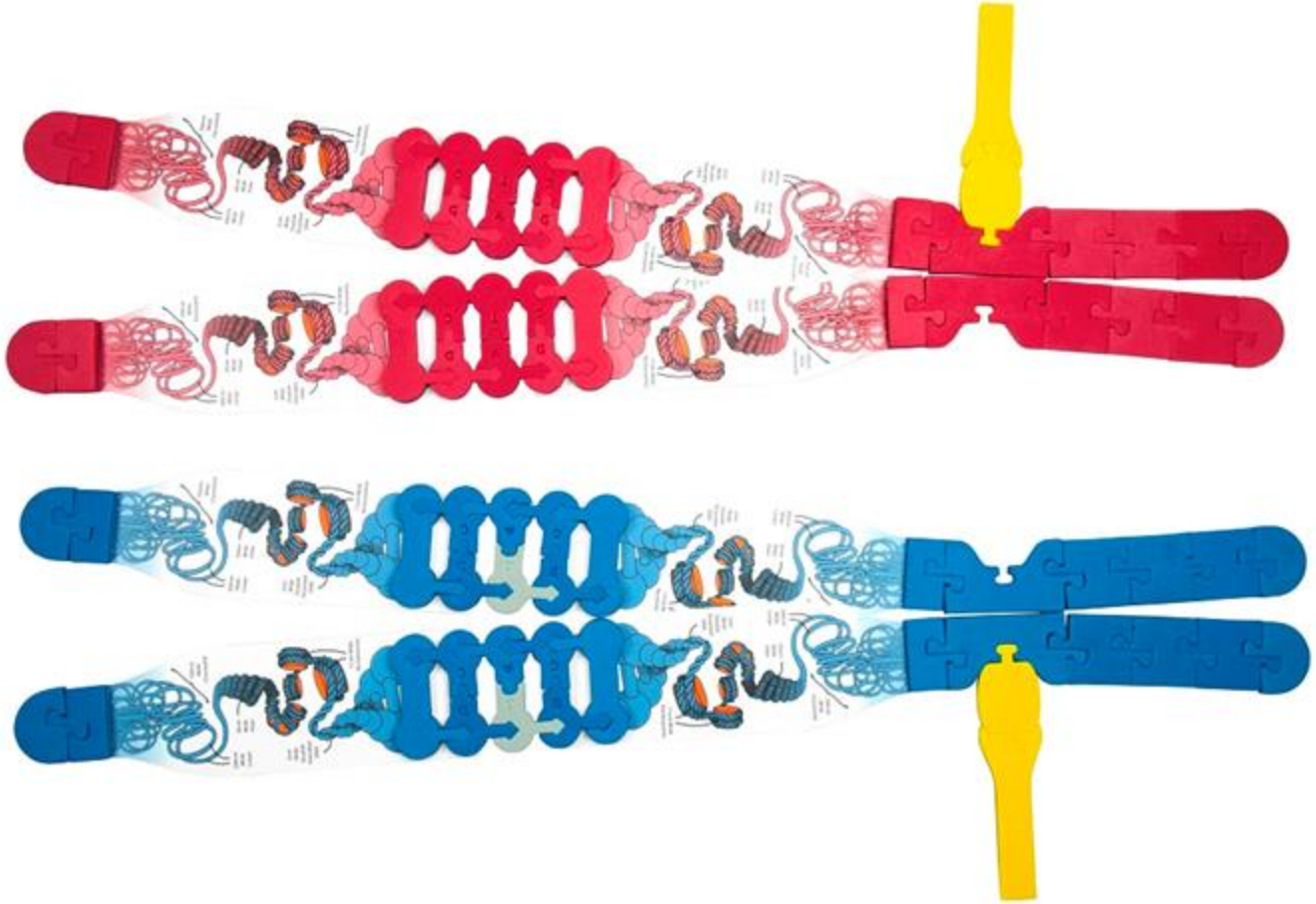
Workshop Learning Goals

- Model chromosome structure and anatomy
- Compare and contrast mitosis and meiosis
- Model mechanisms that contribute to genetic variation
- Construct Punnett squares to connect inheritance of traits to chromosomes at the molecular level

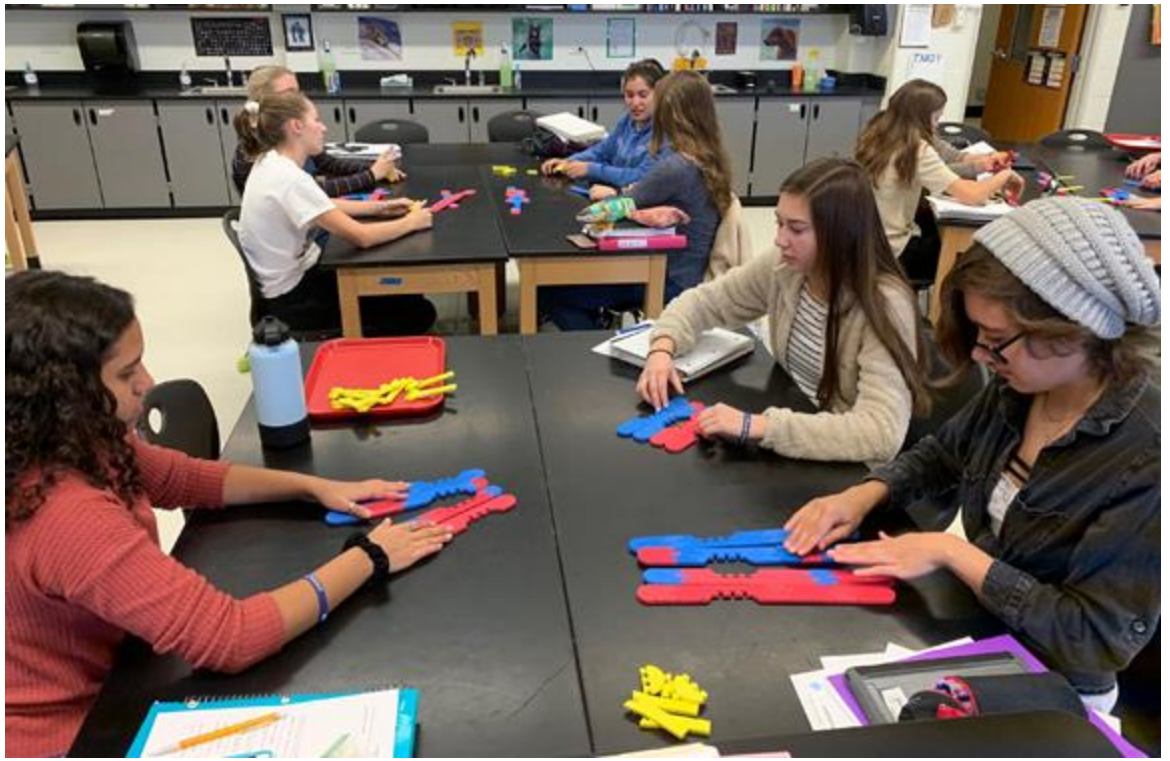
Which grades/subjects do you teach?

Why Models?

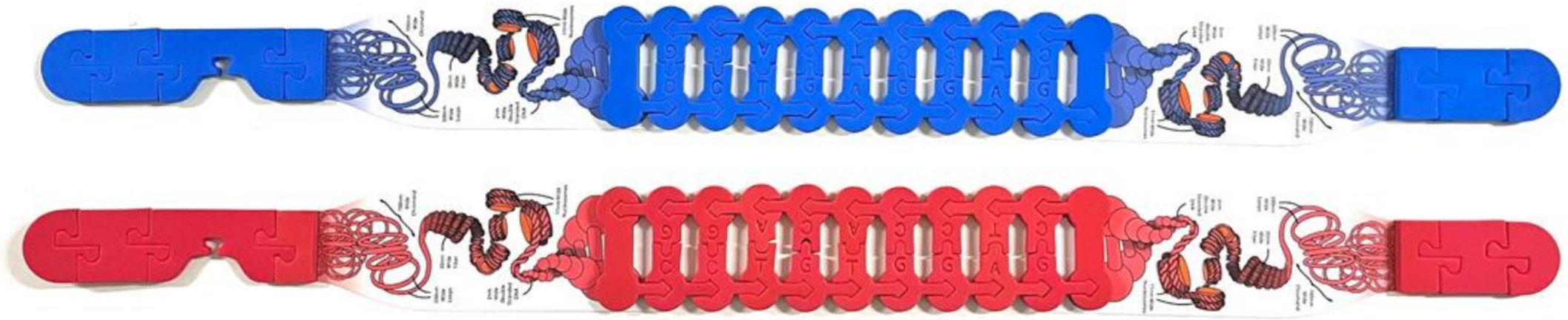
Chromosome Connections Kit©



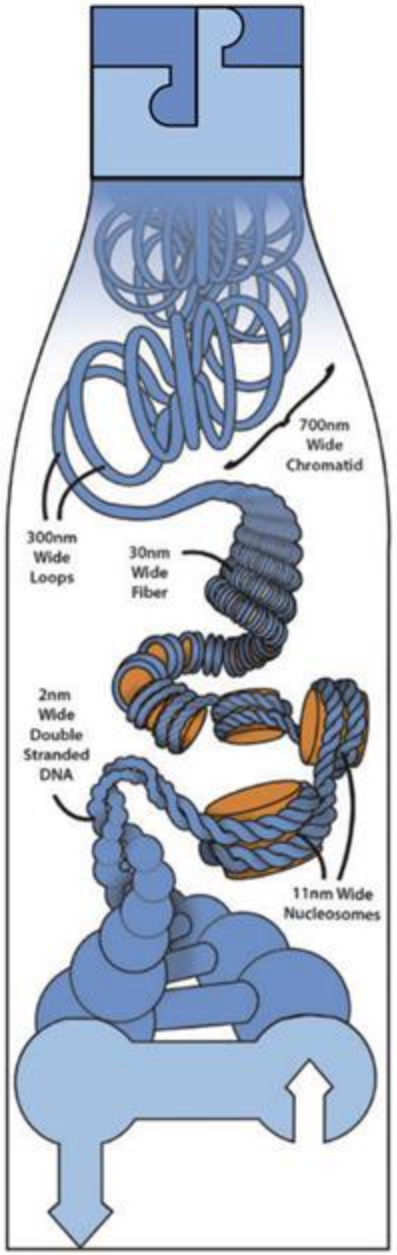
Chromosome Connections Kit©



Let’s construct a model of a chromosome.



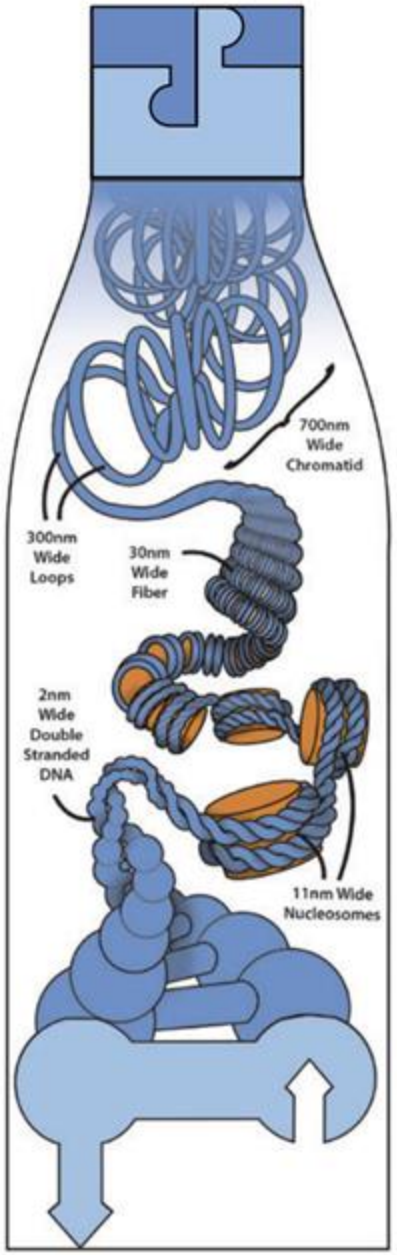
What do you notice? What do you wonder?

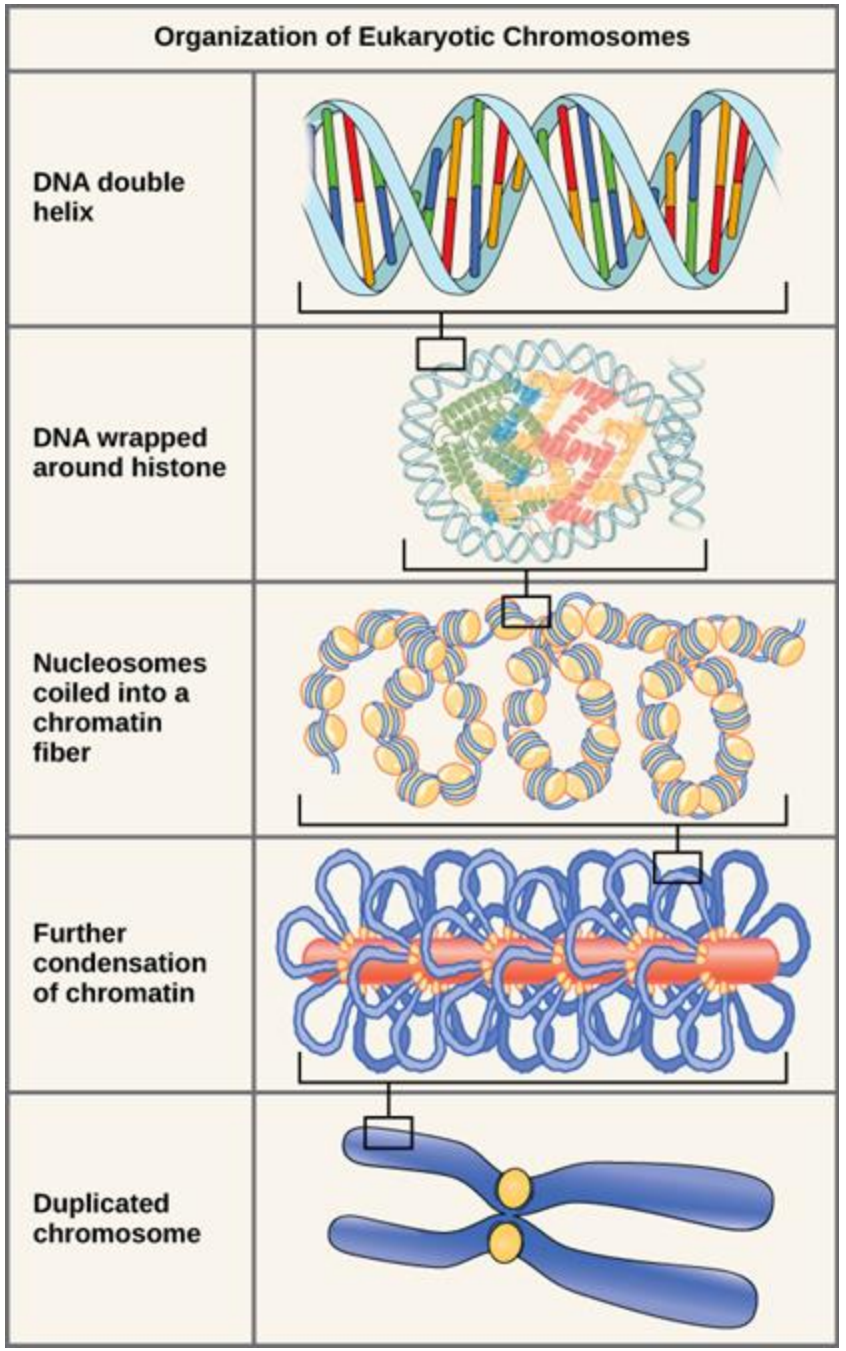


Let's focus on this particular part of the model.

What do you notice?

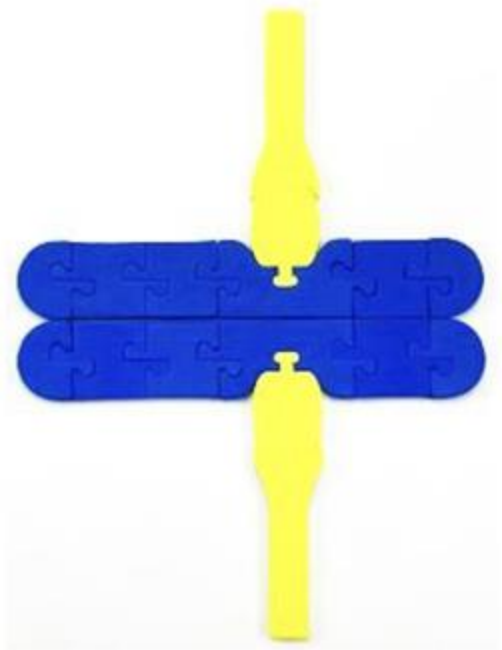
What do you wonder?


700nm
Wide
Chromatid
300nm
Wide
Loops
30nm
Wide
Fiber
2nm
Wide
Double
Stranded
DNA
11nm Wide
Nucleosomes


Organization of Eukaryotic Chromosomes
DNA double helix
DNA wrapped around histone
Nucleosomes coiled into a chromatin fiber
Further condensation of chromatin
Duplicated chromosome

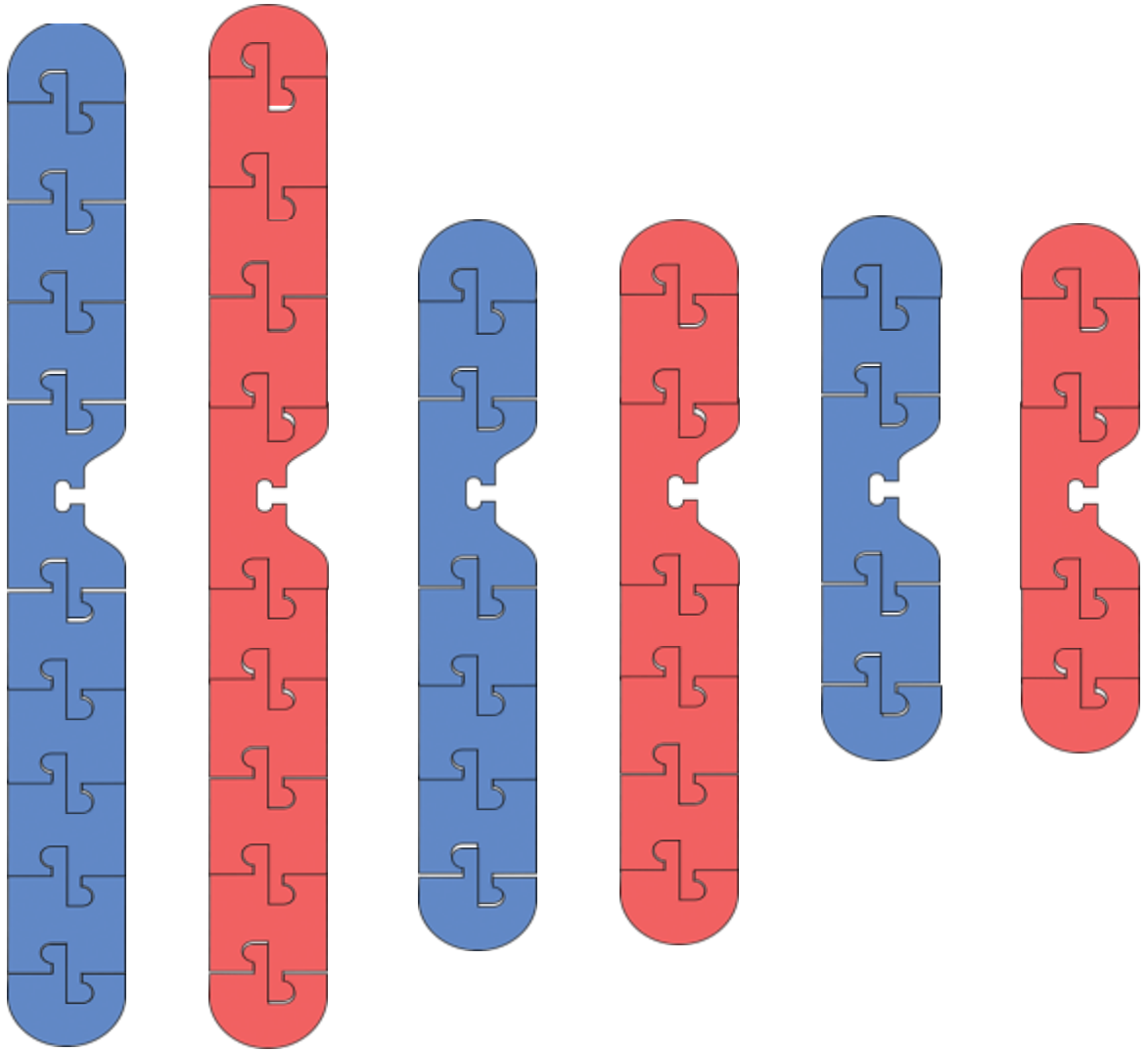
Comparing Chromosomes: Microscopic Scale vs. Molecular Scale

Microscopic Scale

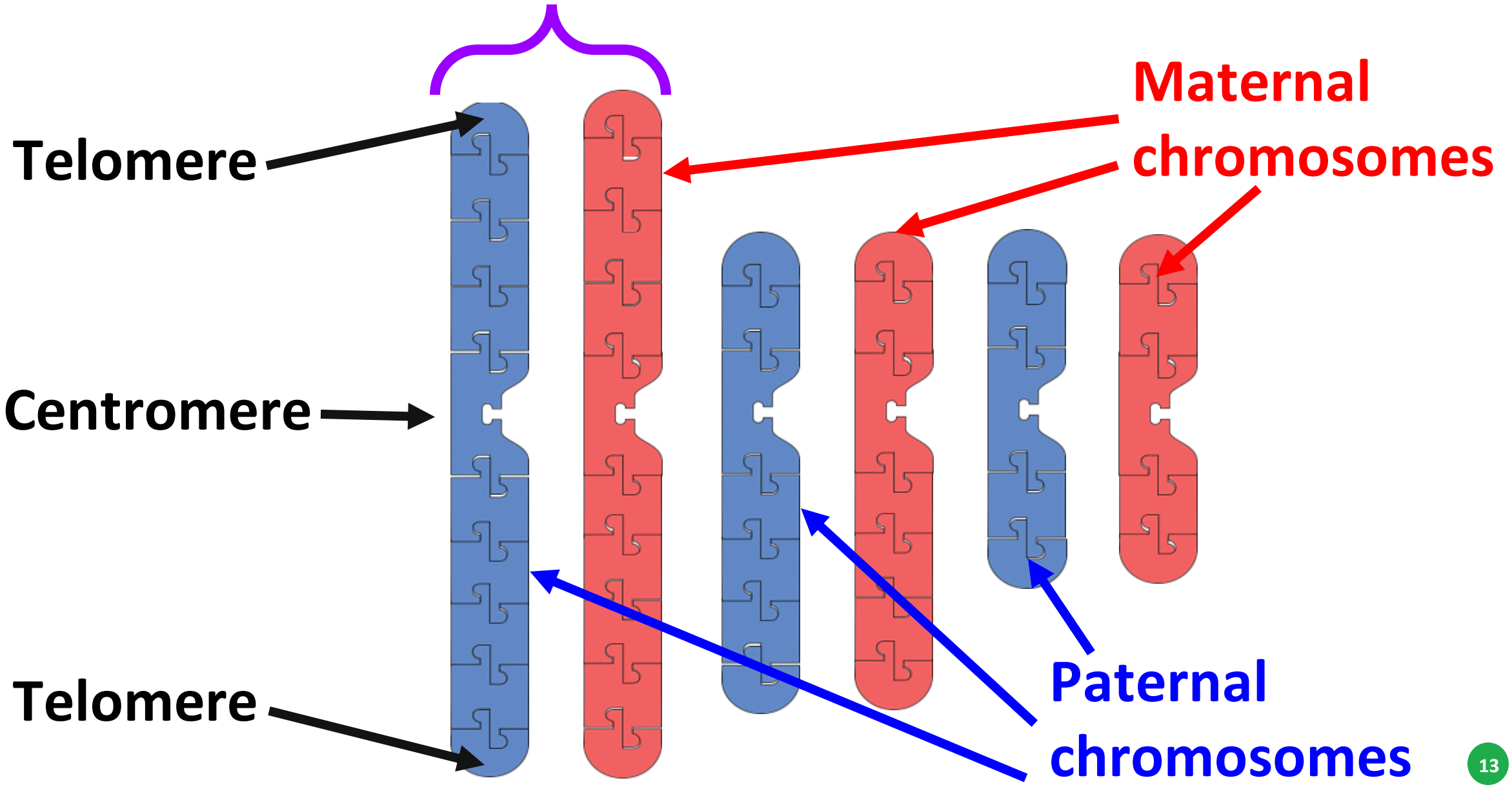


Molecular Scale

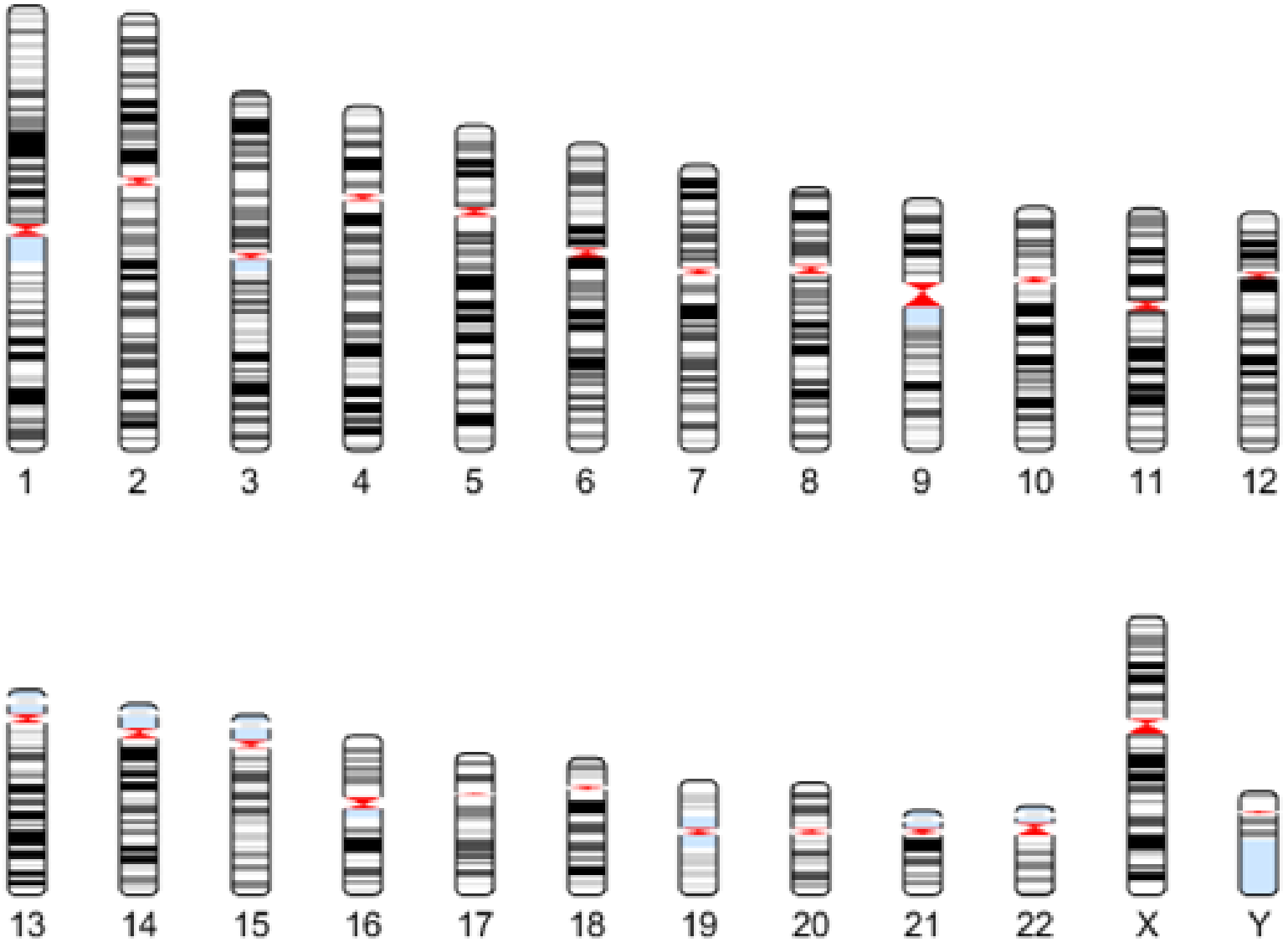
Construct 6 chromosomes:

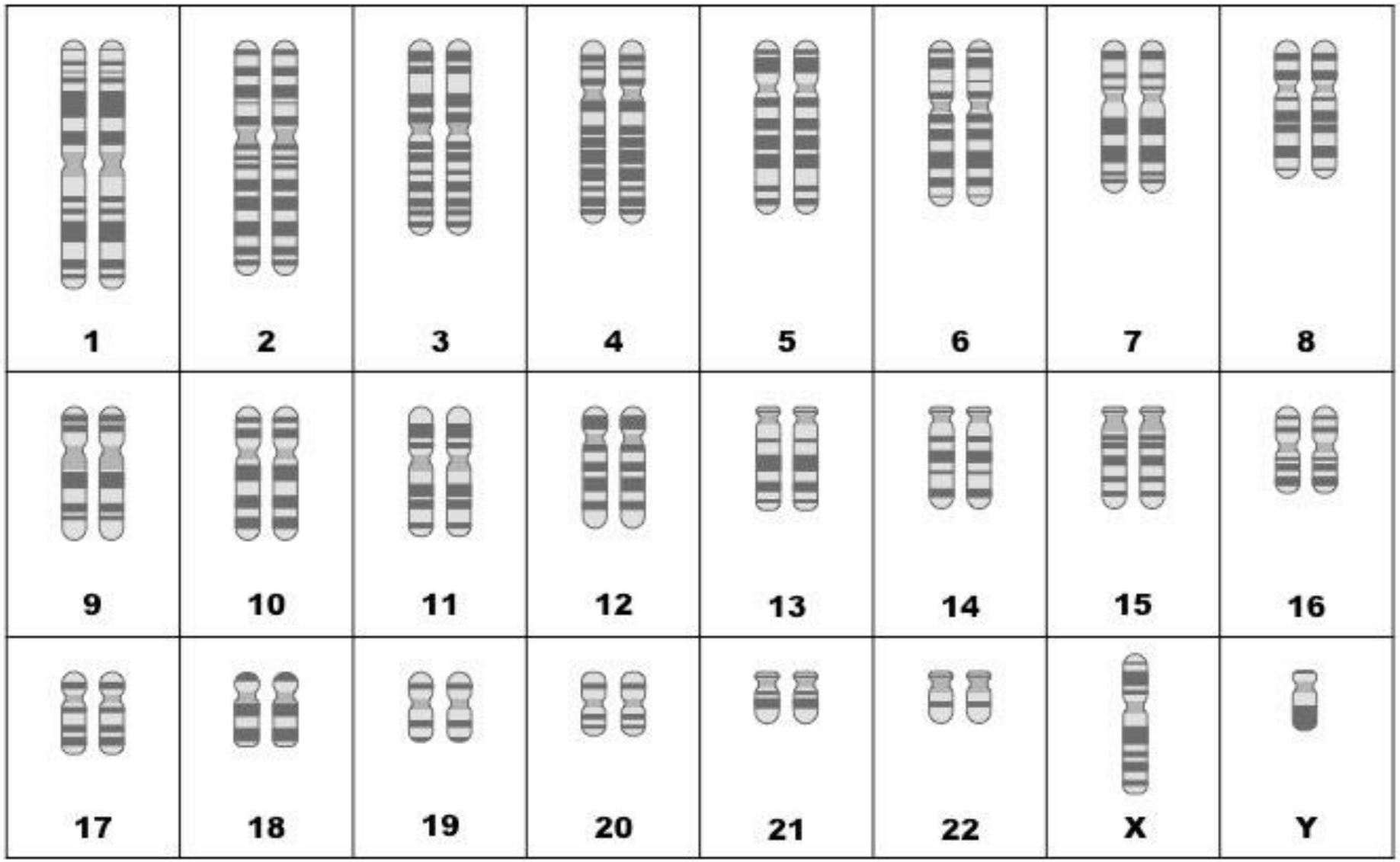


Homologous chromosomes



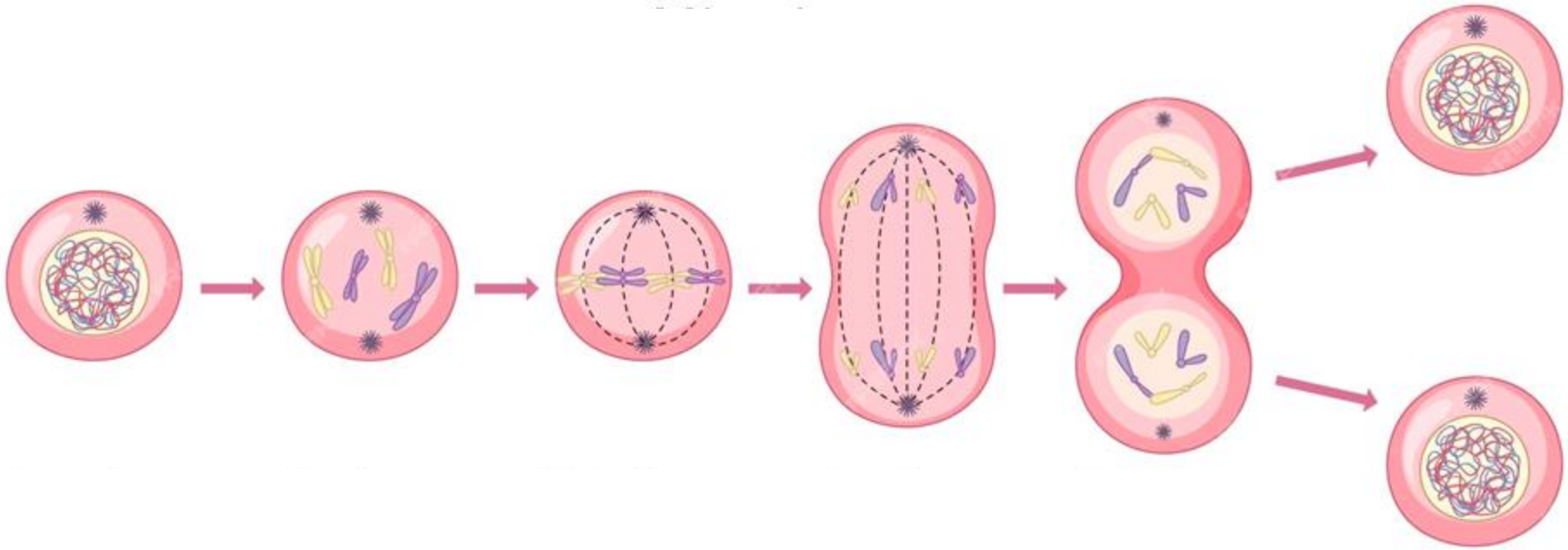
Karyogram



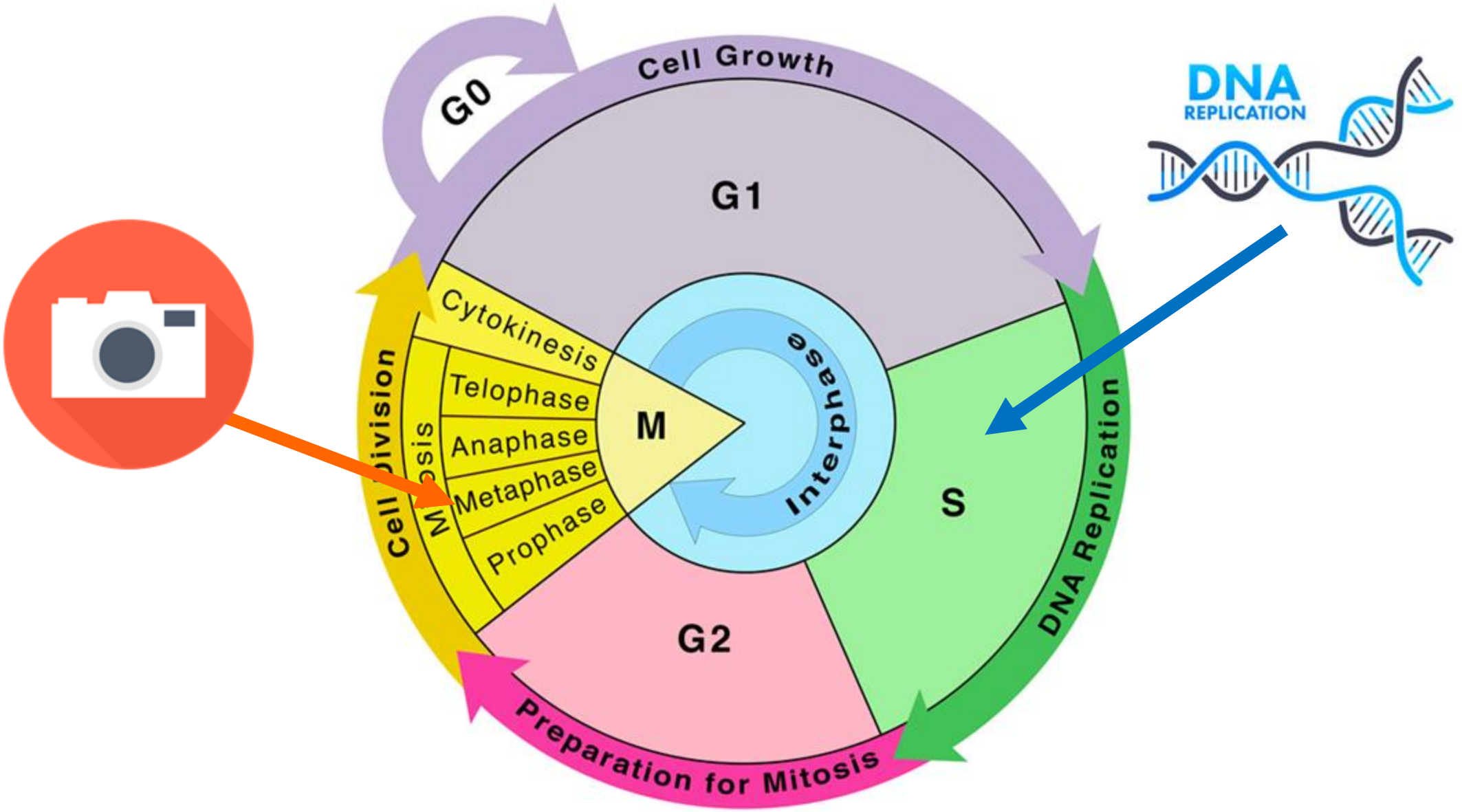

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X
Y

Human Karyotype

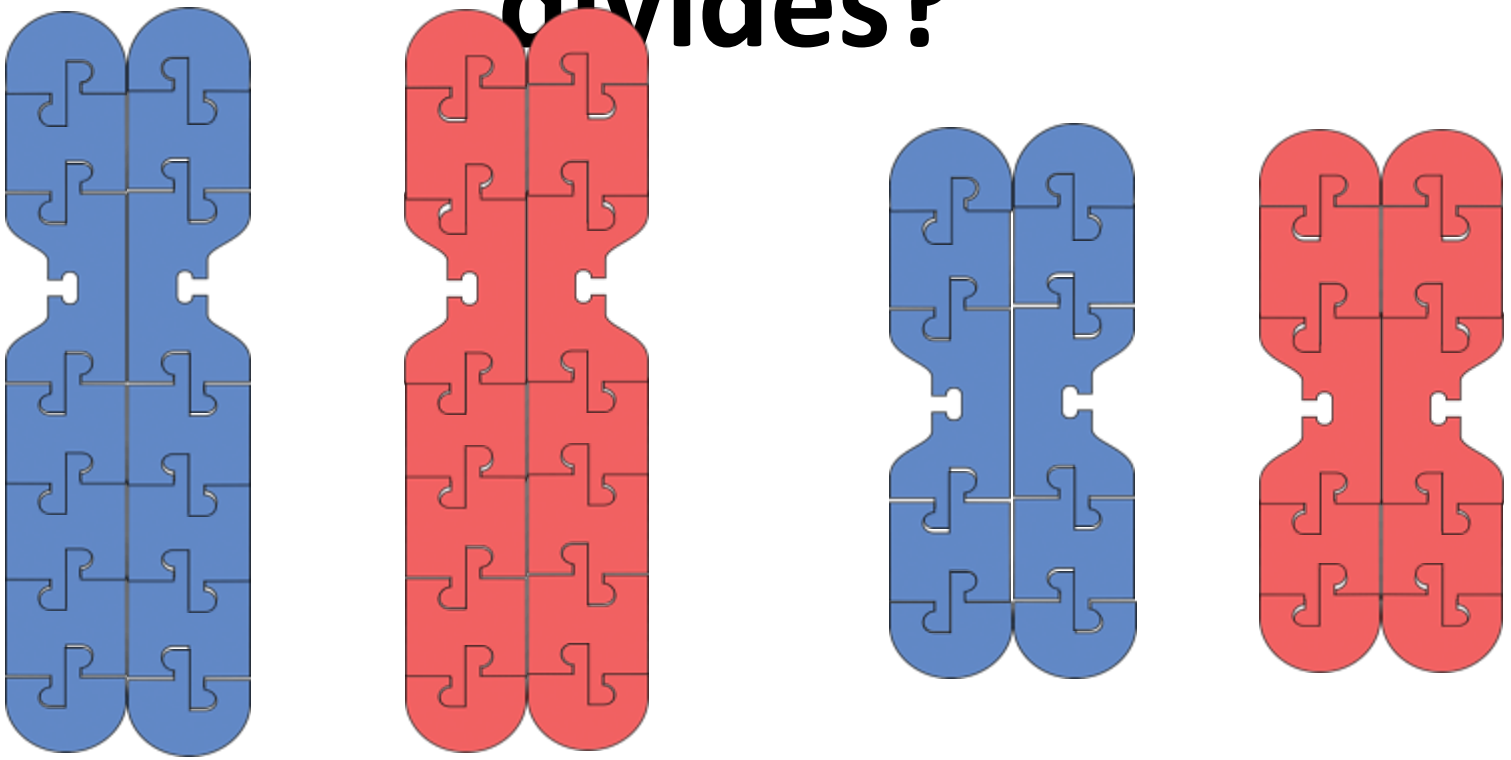
What happens to chromosomes during cell division?



Cell Cycle


G0
Cell Growth
G1
Cytokinesis
Telophase
Anaphase
Metaphase
Prophase
M
Interphase
S
DNA Replication
G2
Preparation for Mitosis
Cell division
DNA
REPLICATION

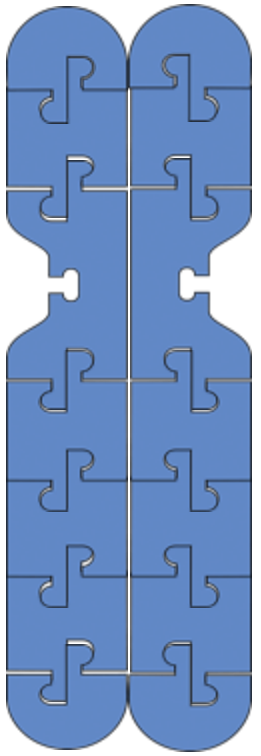
What happens to chromosomes before a cell divides?

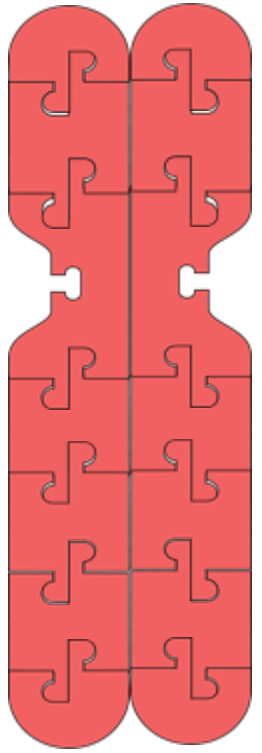


Each chromosome = 2 identical sister chromatids

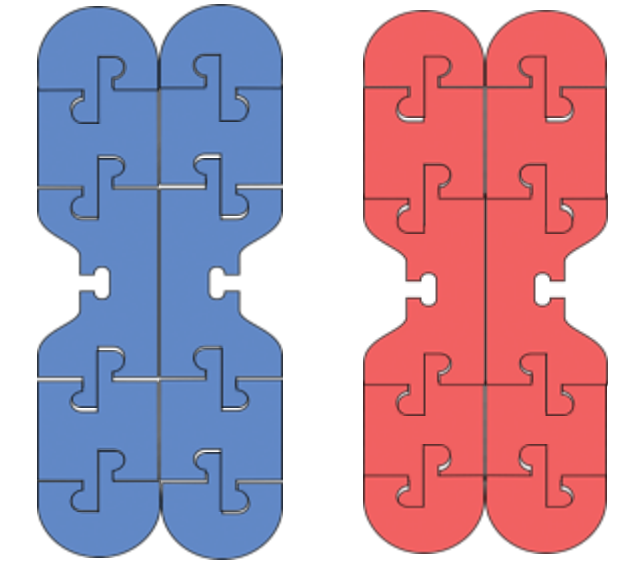
chromosome (replicated)

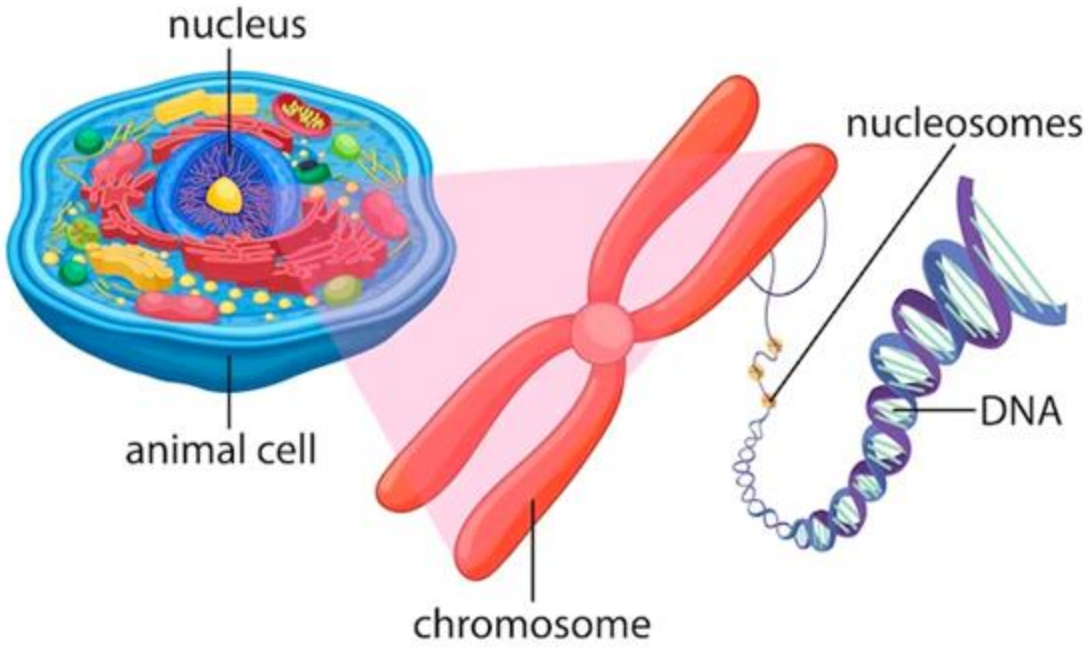
chromosome (replicated)



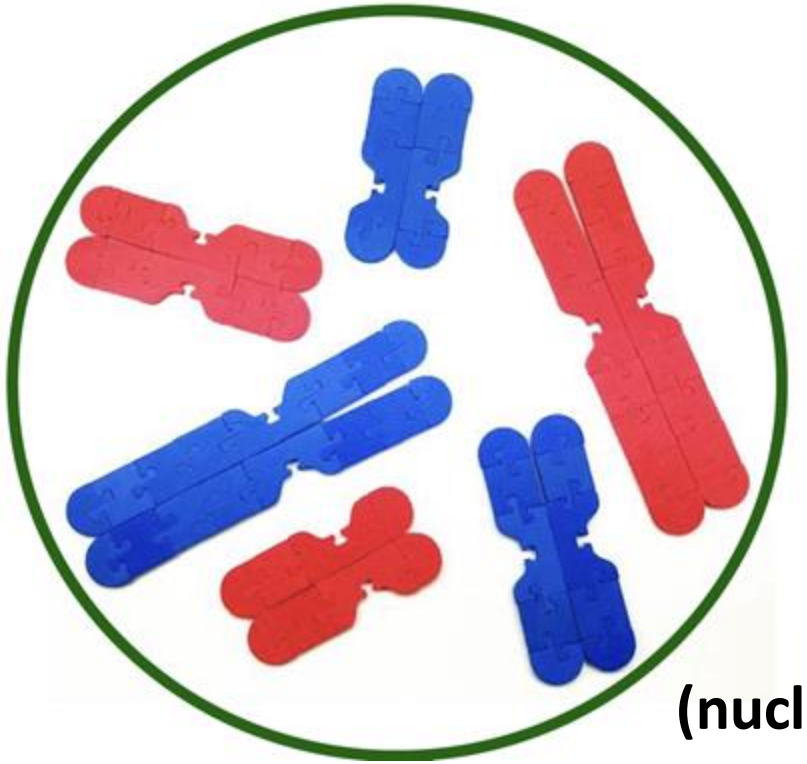


Homologous chromosomes





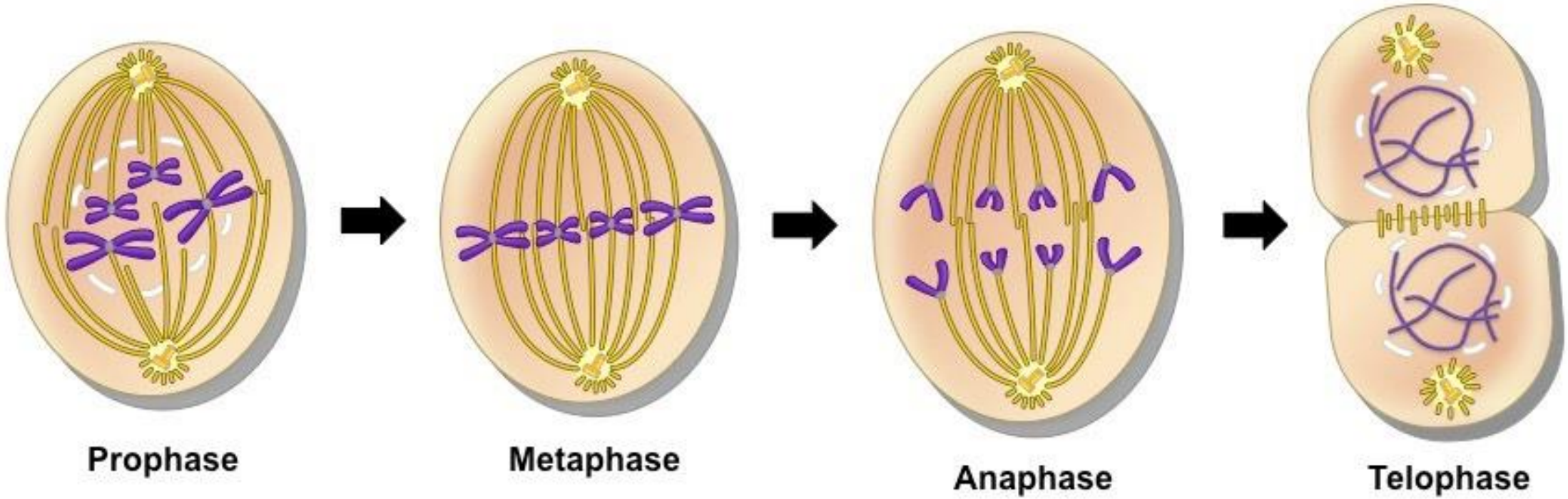
Parent Cell Chromosomes

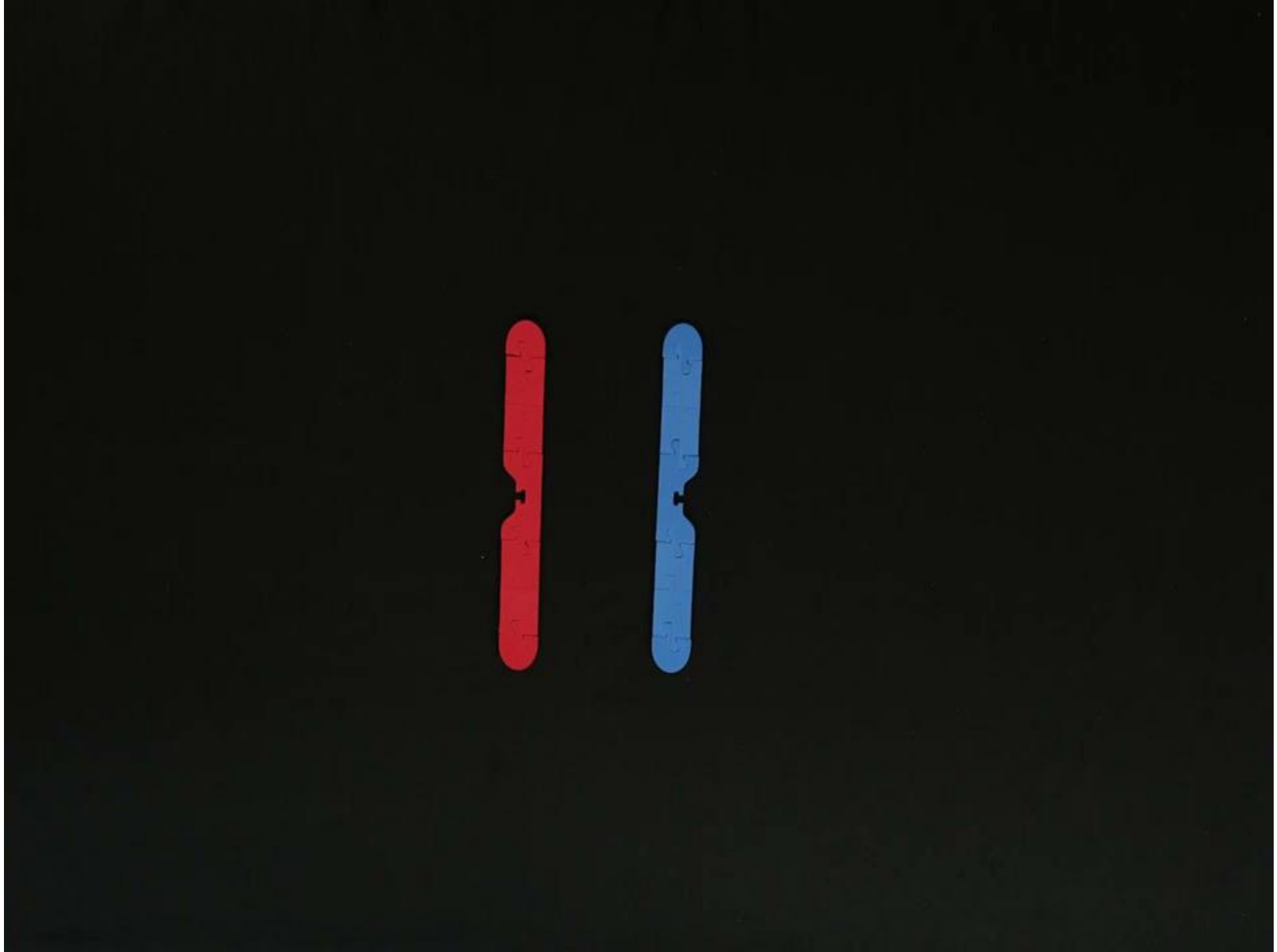


Diploid Cell
2n = 6

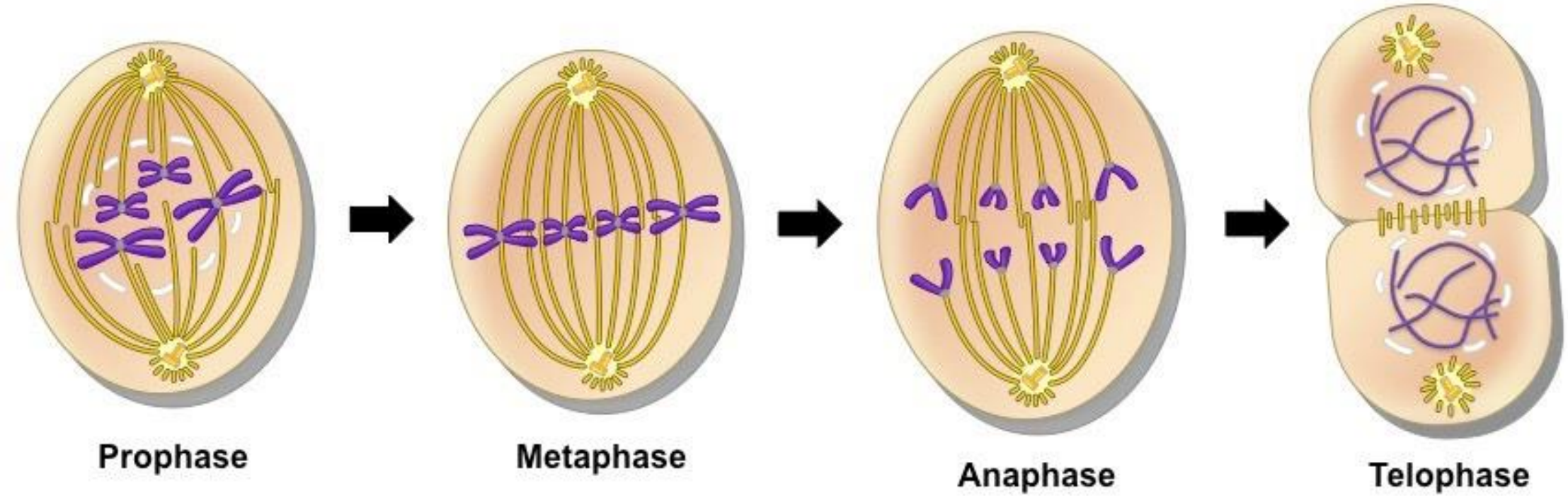
(nucleus)

Modeling Mitosis





Move your chromosomes to model the process of Mitosis

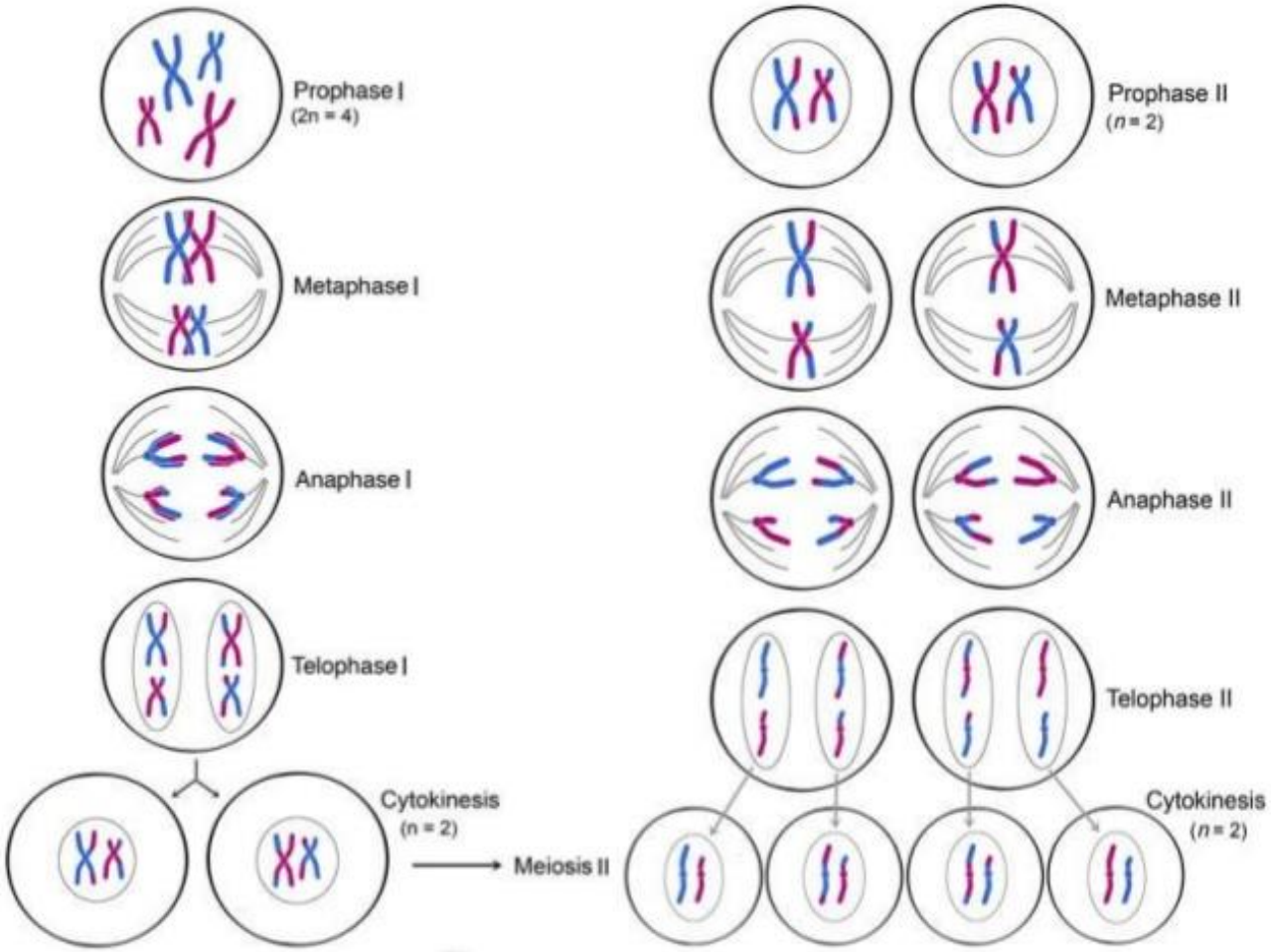


- As a learner, what are some *"Aha Moments"* that arose for you during this activity?
- What are some things you *wondered* about as you modeled mitosis?
- What are some *driving questions* that you could pose to your class where this activity would be useful as you investigate a specific problem?

Questions to ask your students:

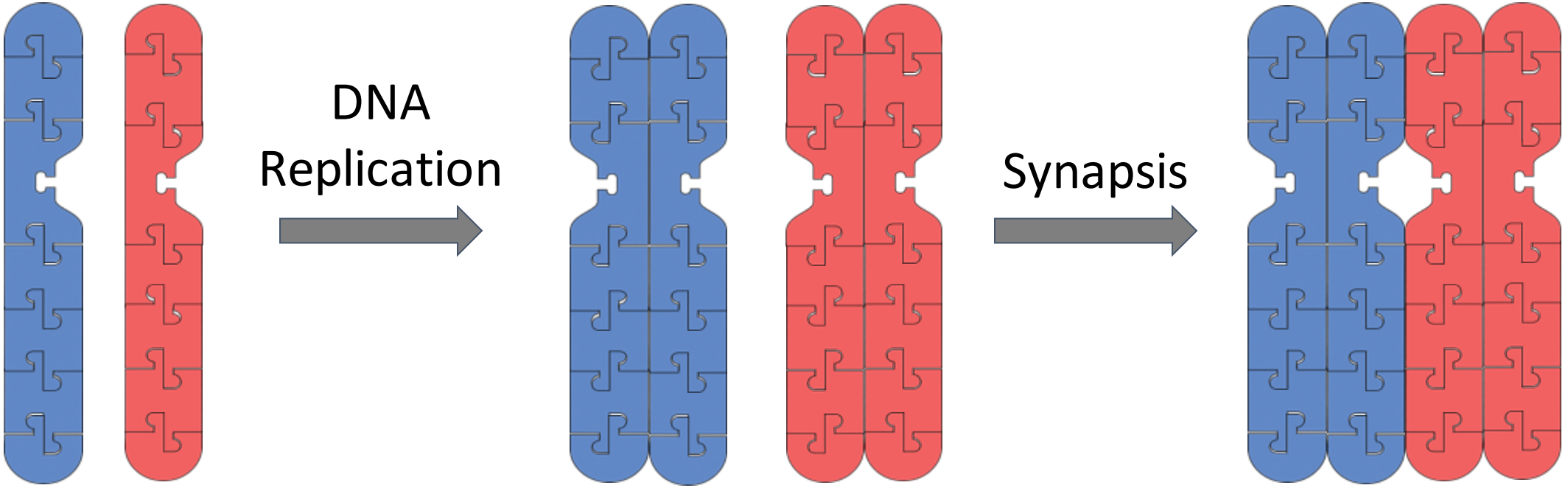
- How do the daughter cells compare to the original parent cell?
- How many chromosomes were in each parent cell?
- How many *chromatids* were in the cell during prophase?
- How many chromosomes are in each daughter cell?

Modeling Meiosis



Interphase

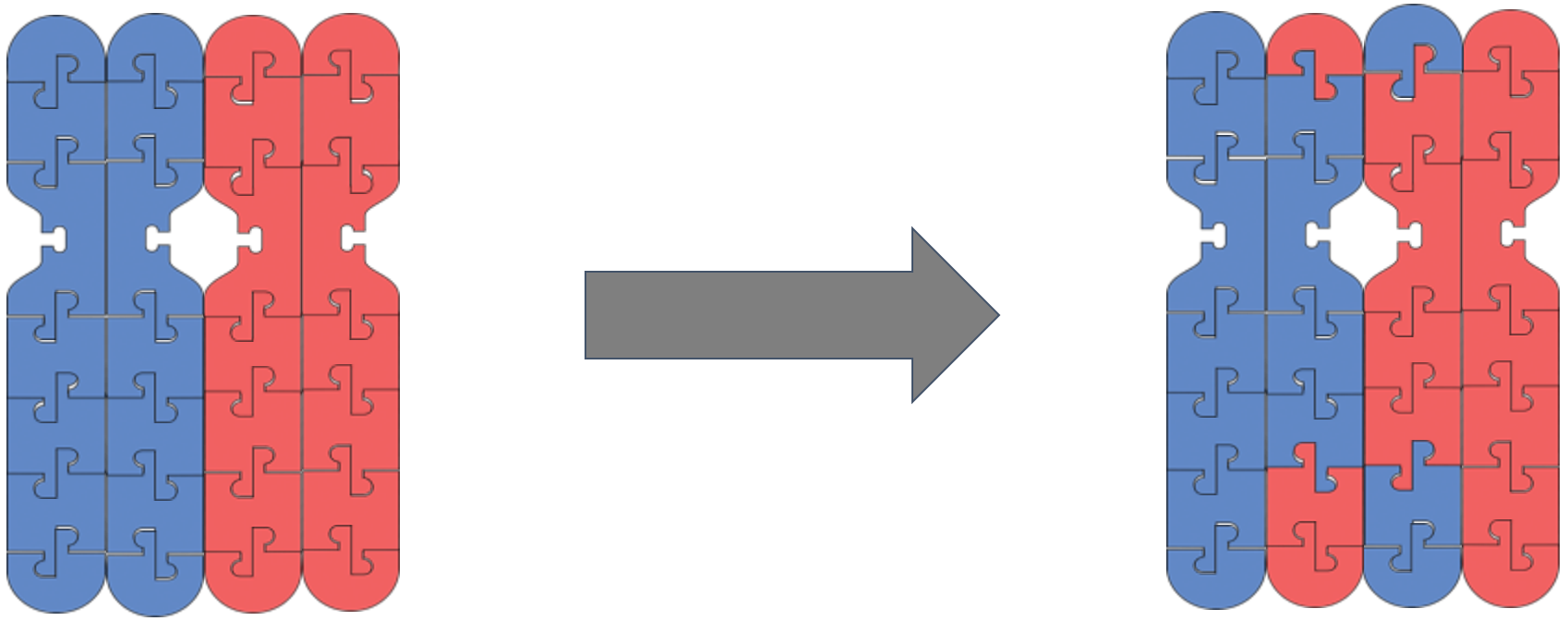
Prophase I



replicated chromosomes (chromatin condenses to form chromosomes)

pairing of homologous chromosomes

Prophase I - Crossing Over



tetrad = 4 chromatids

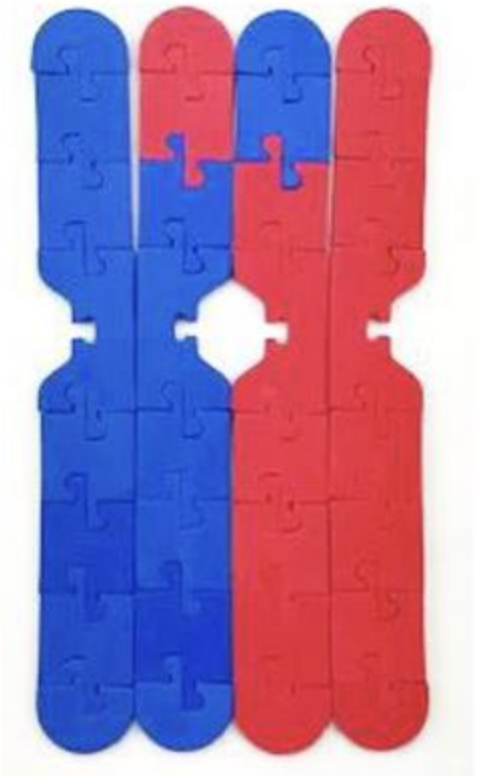
crossing over between non-sister chromatids

Crossing Over

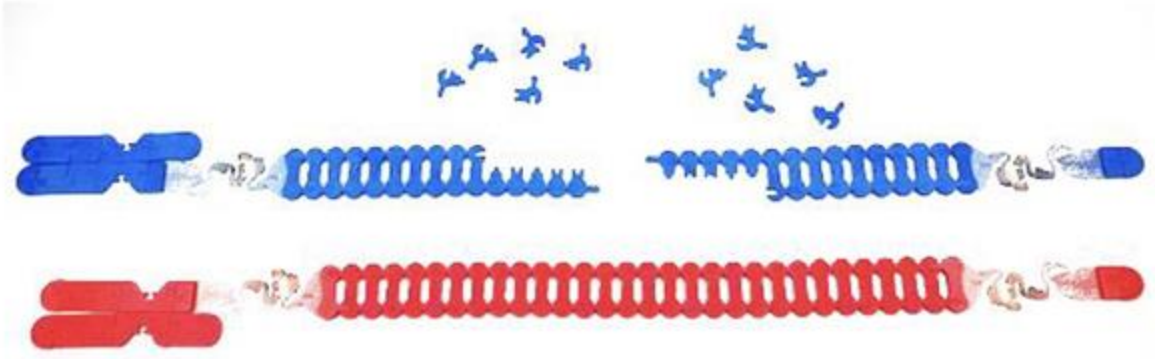
What are some limitations of this model?

Crossing Over

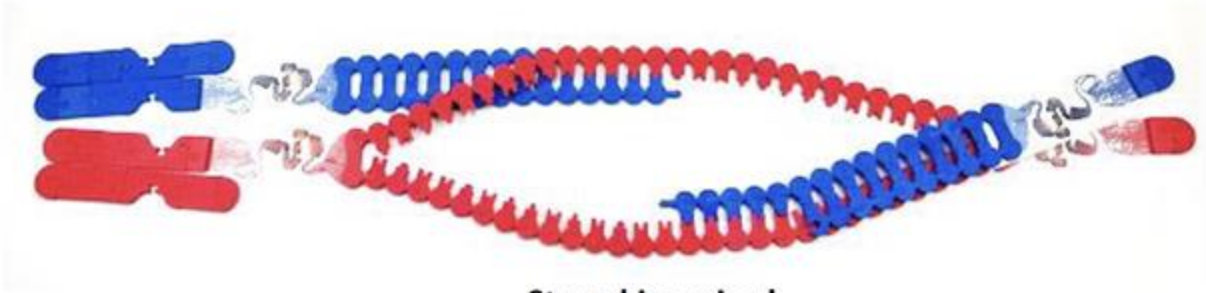
Microscopic Scale



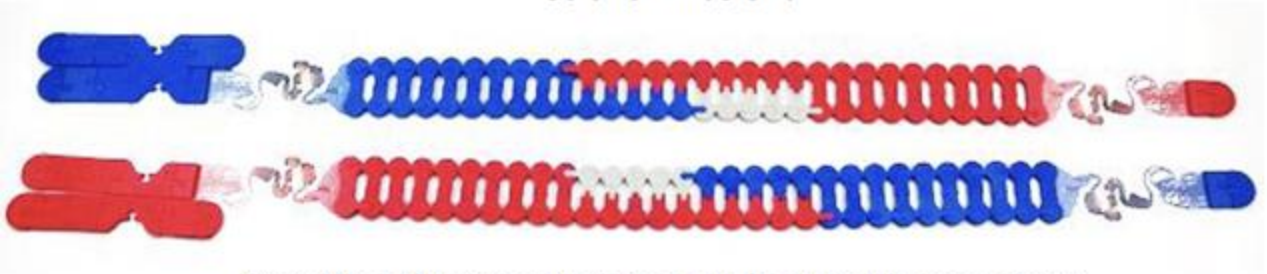
Molecular Scale



A double stranded cut with nuclease digestion.



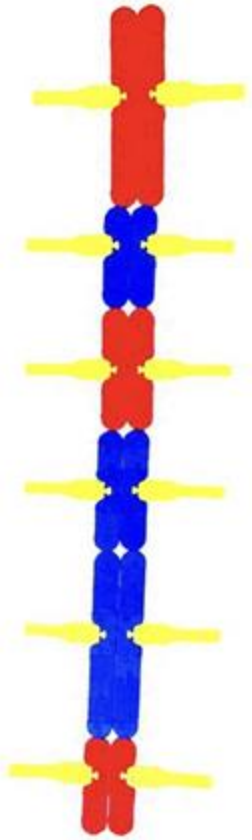
Strand invasion!



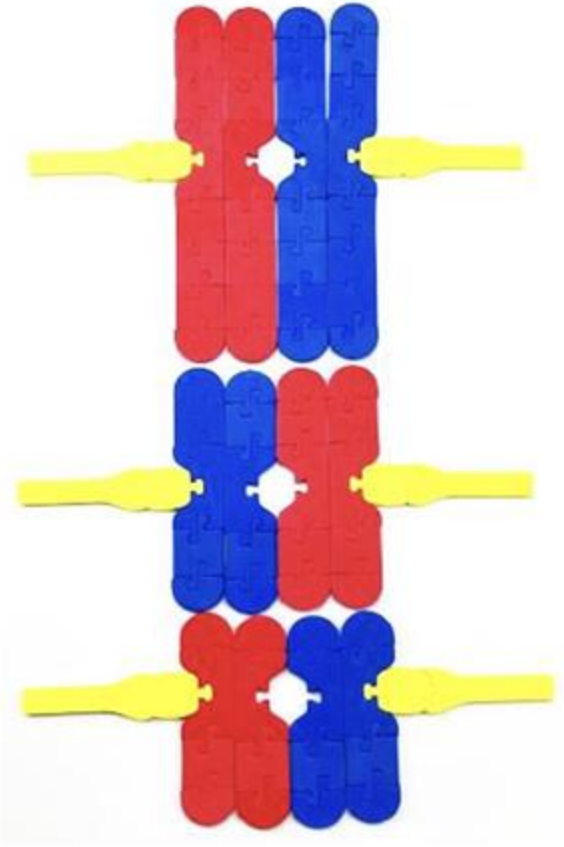
Resulting chromosomes in a single crossing over event.

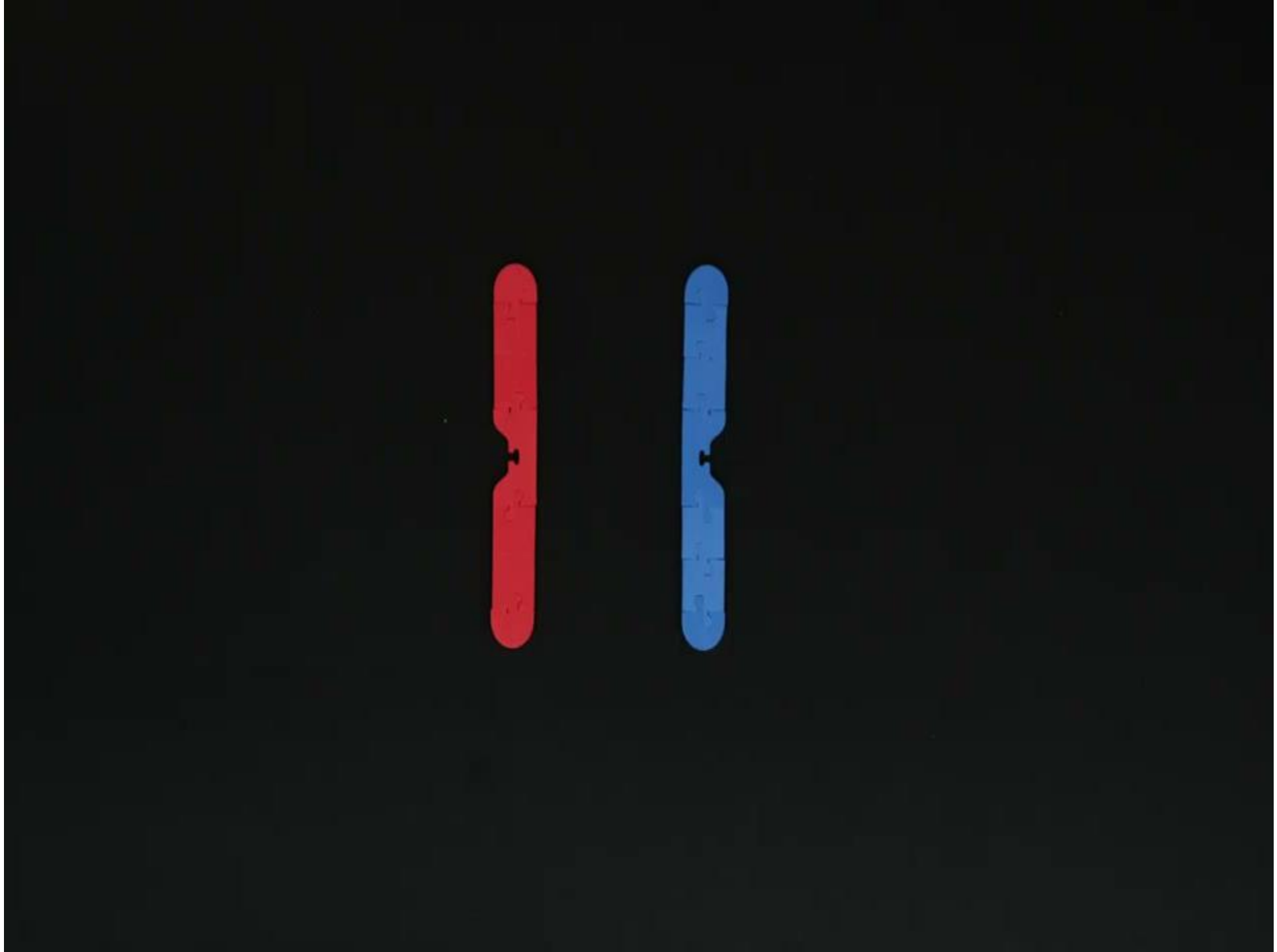
How does Metaphase (in Mitosis) differ from Metaphase I (in Meiosis)?

Mitosis - Metaphase

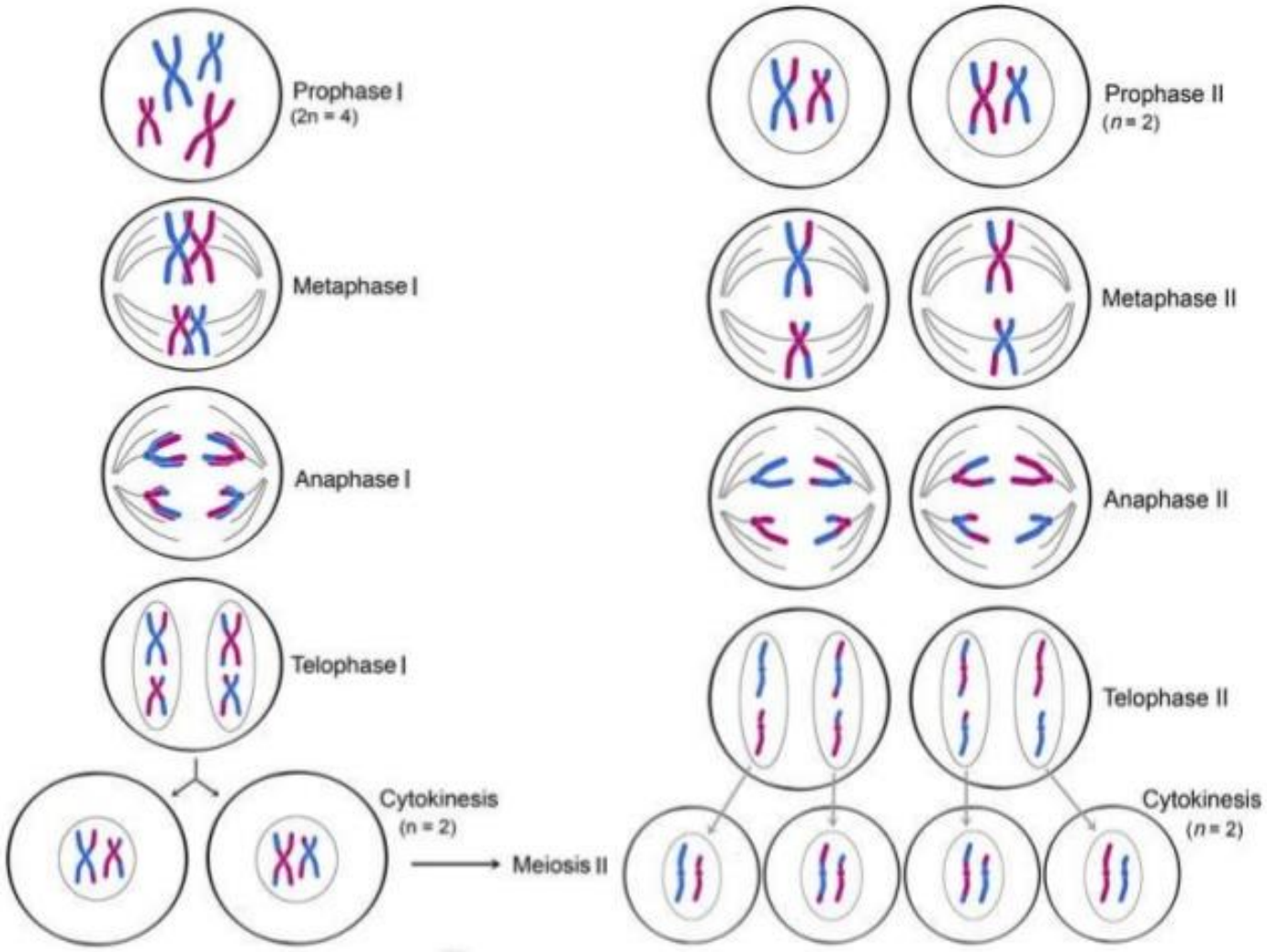


Meiosis - Metaphase I





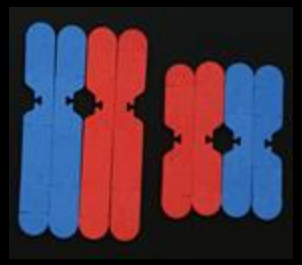
Move your chromosomes to model 2 divisions: Meiosis I and Meiosis II

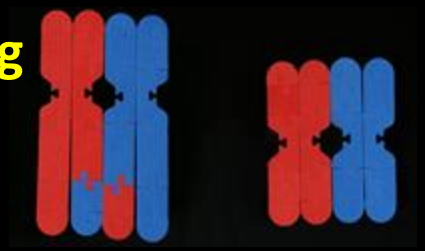


Meiosis I

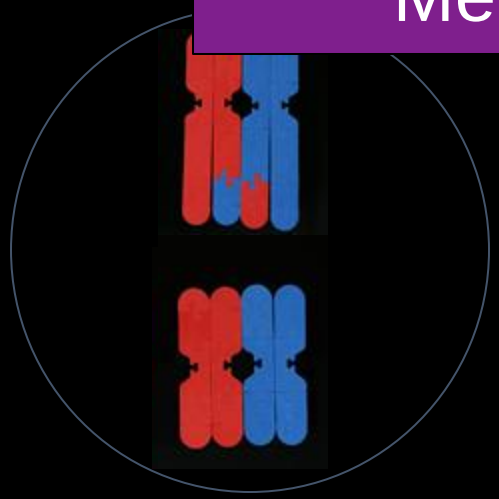
synapsis

crossing over

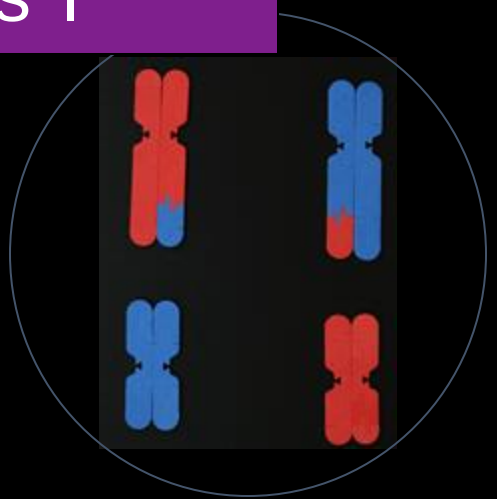




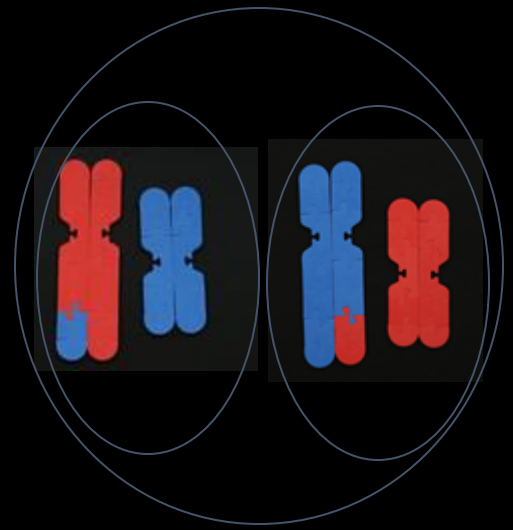
Prophase I



Metaphase I

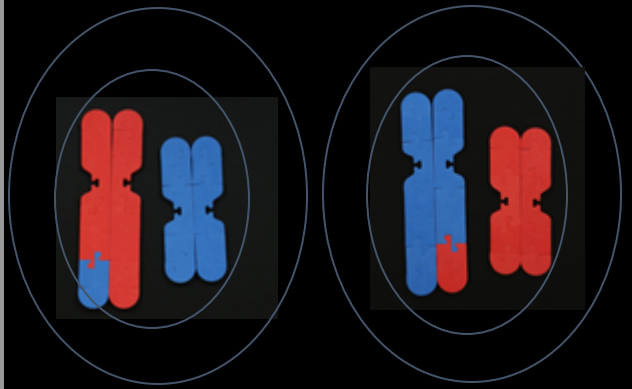


Anaphase I

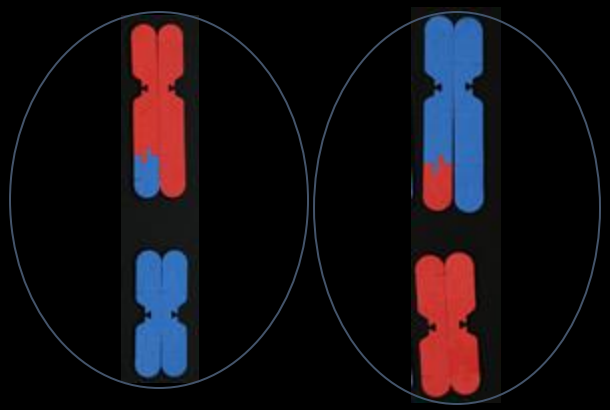


Telophase I

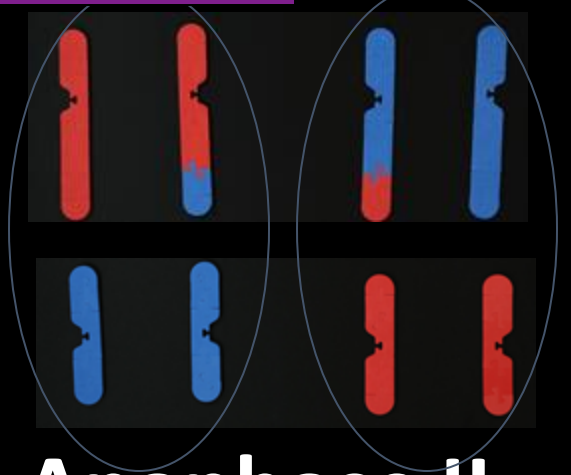
Meiosis II



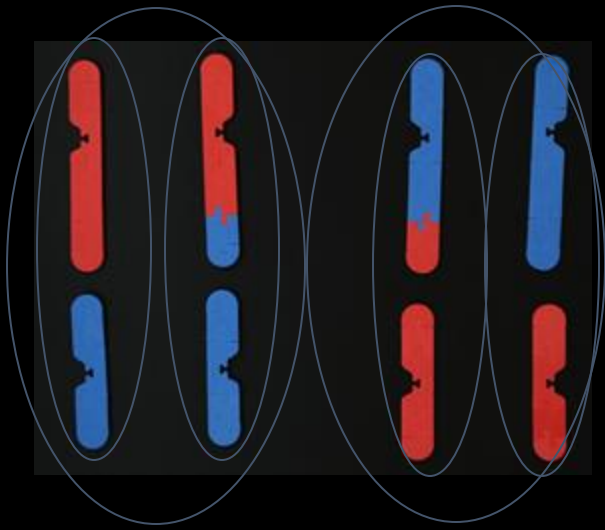
Prophase II



Metaphase II



Anaphase II



Telophase II

What are some “Aha Moments” *you* experienced as a learner during this activity?

- What are some probing questions that you might ask your students as they model the process of meiosis?

- What are some specific tasks you could you ask your students to do to demonstrate their understanding of meiosis?

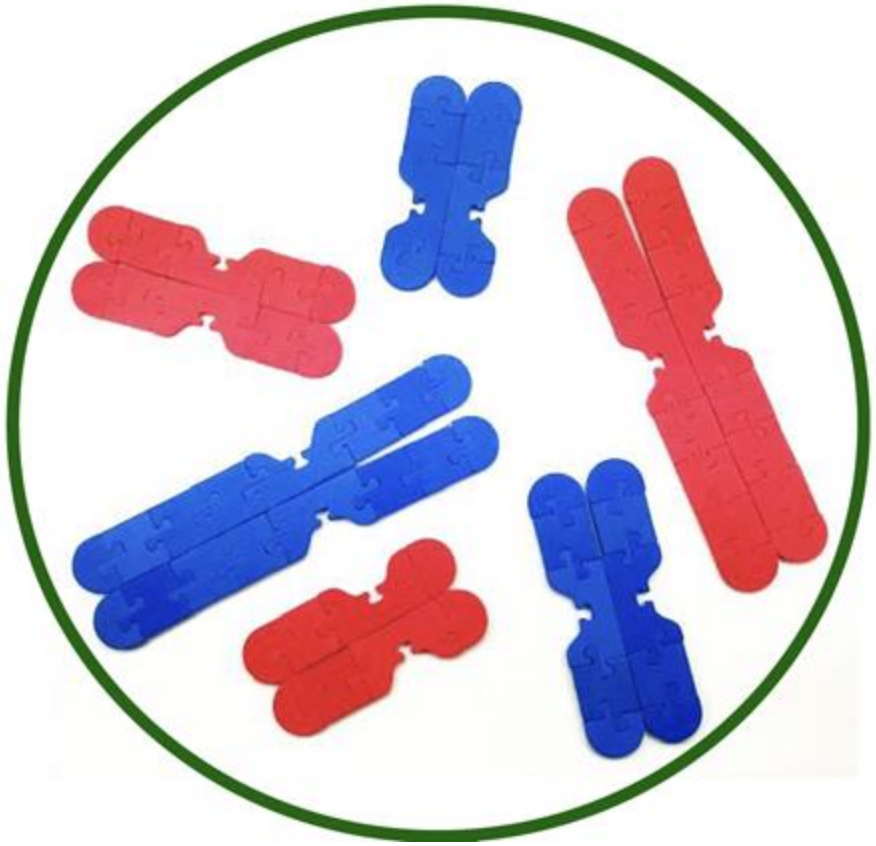
Genetic Variation: Law of Independent Assortment

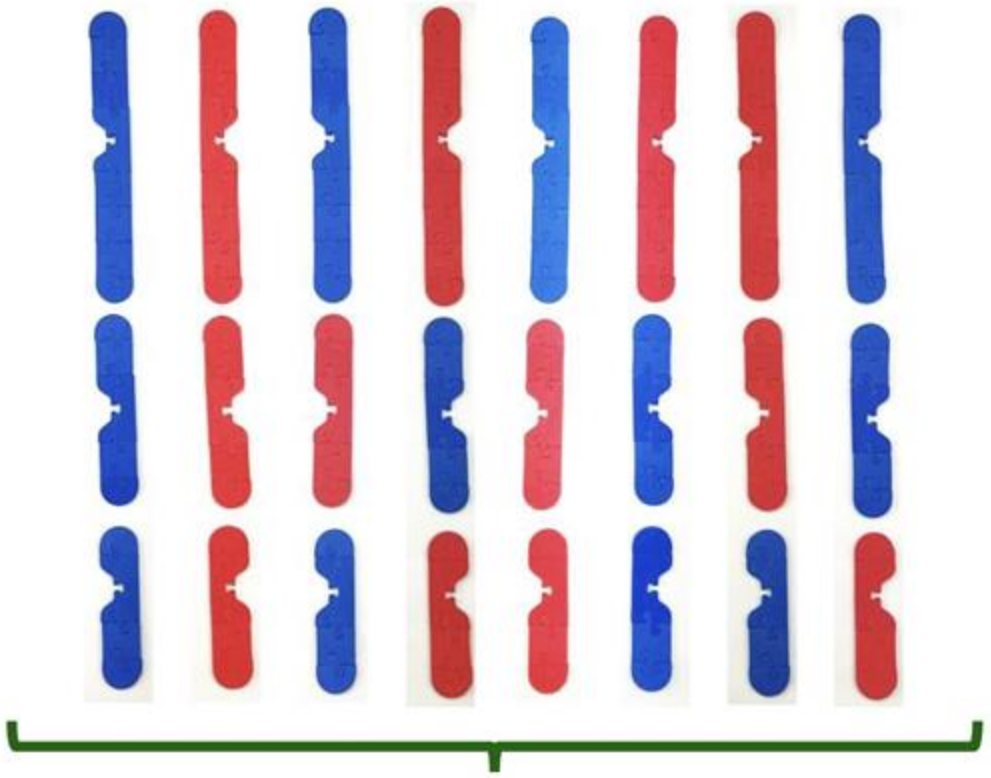
2n (diploid number of chromosomes) = 6

n (haploid number of chromosomes) = 3

2^n (number of possible chromosome combinations after meiosis) = 8

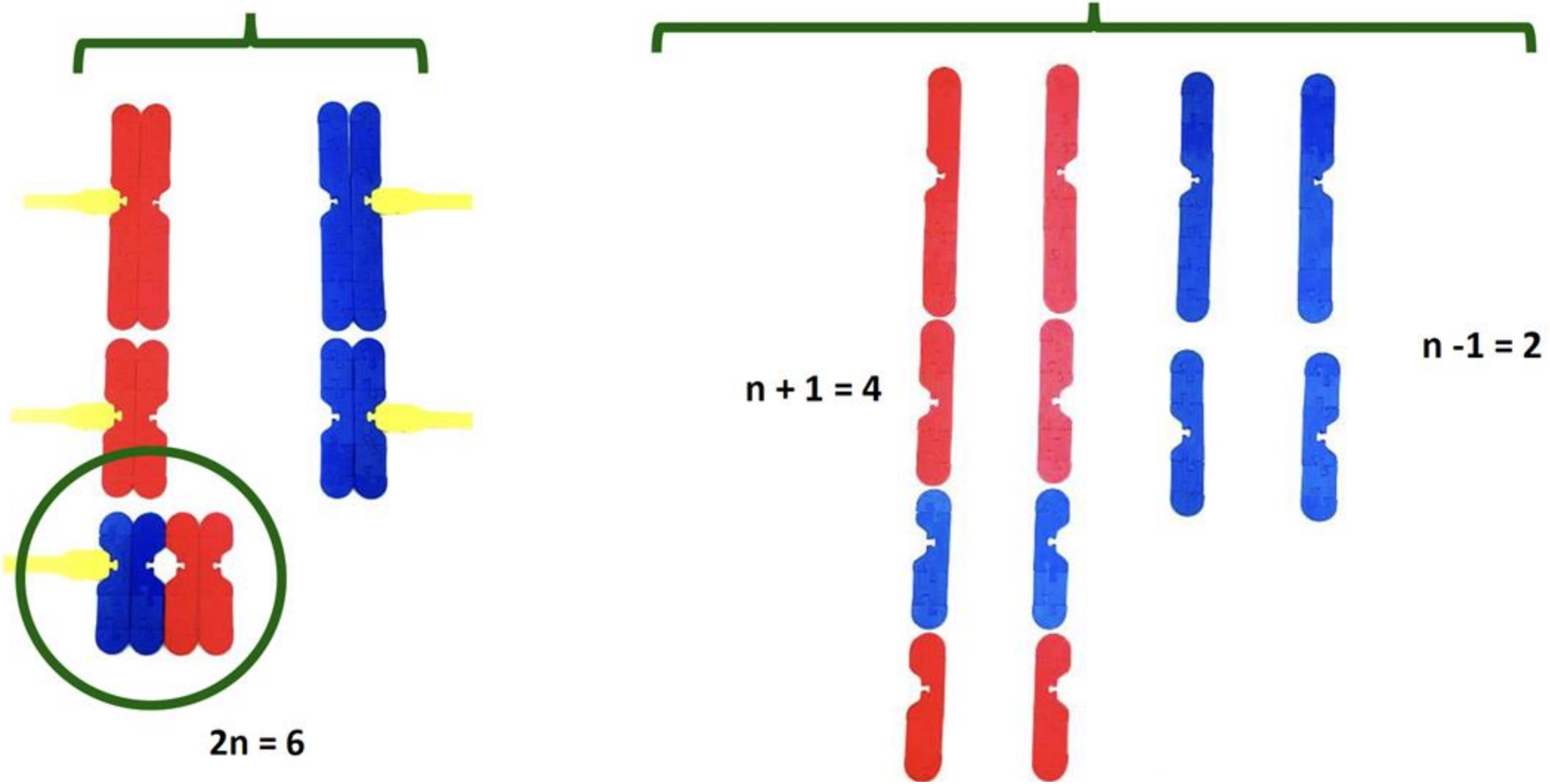
Parent Cell Chromosomes





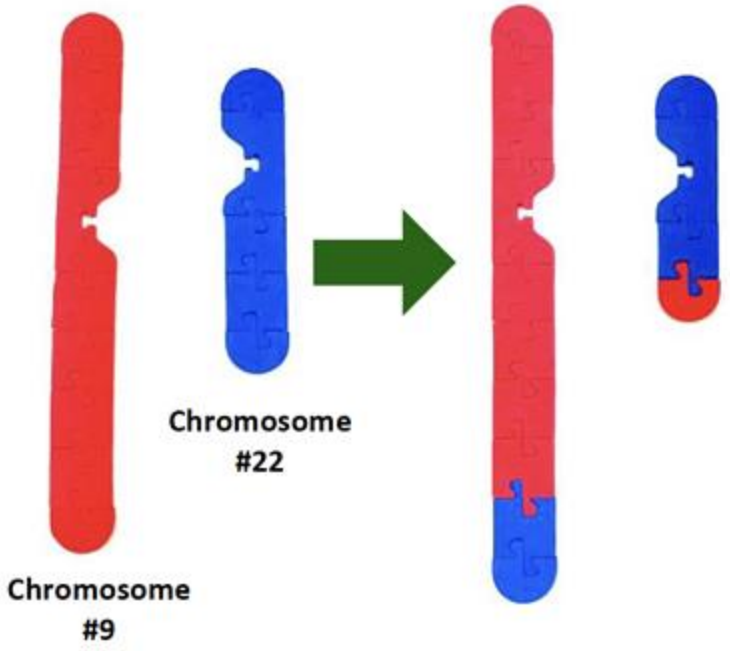
Possible Gametes

Nondisjunction in Meiosis I

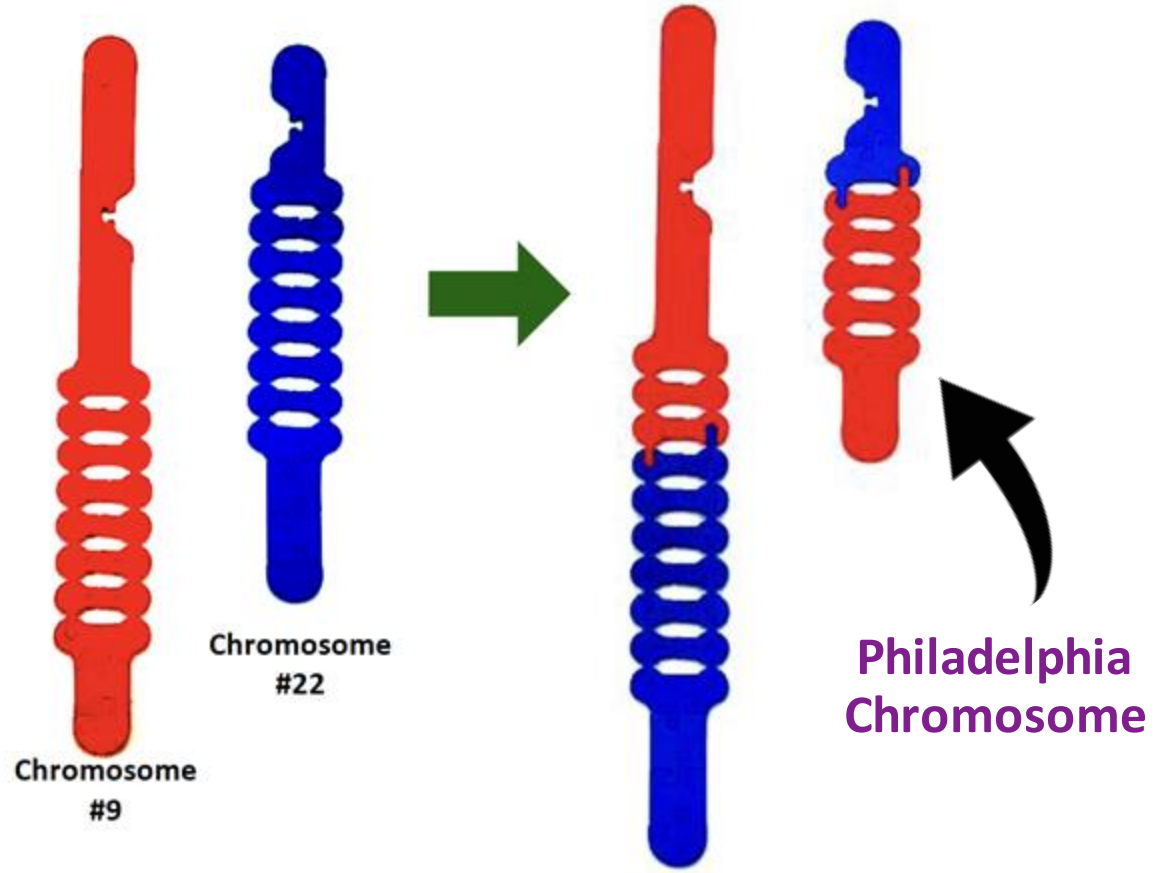


Nondisjunction: Philadelphia Chromosome

Microscopic Scale



Molecular Scale



Formation of a new gene (BCR-ABL) → Chronic myelogenous leukemia

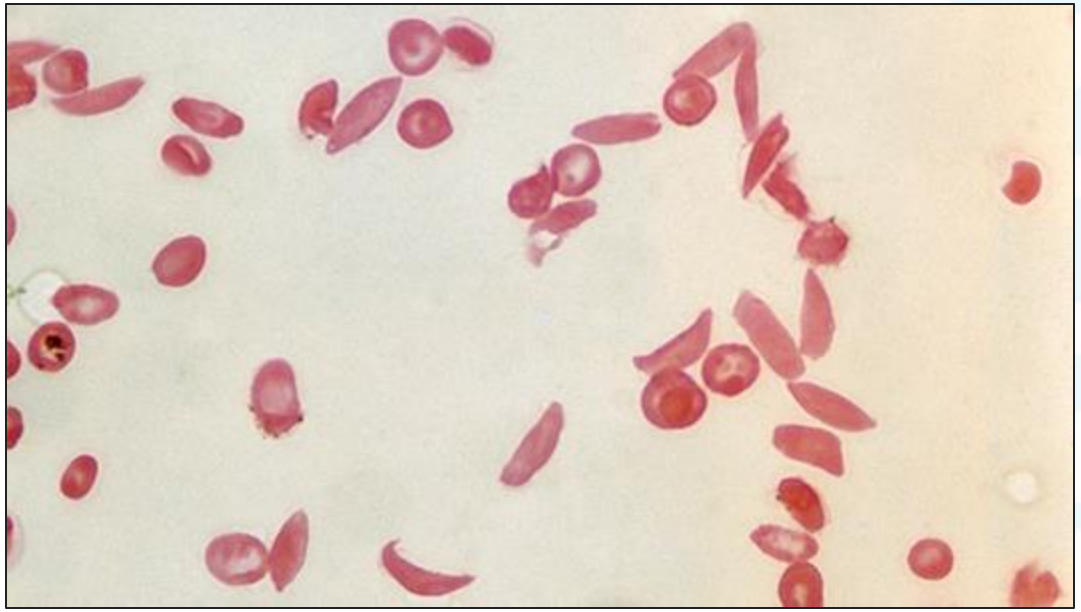
3d molecular designs

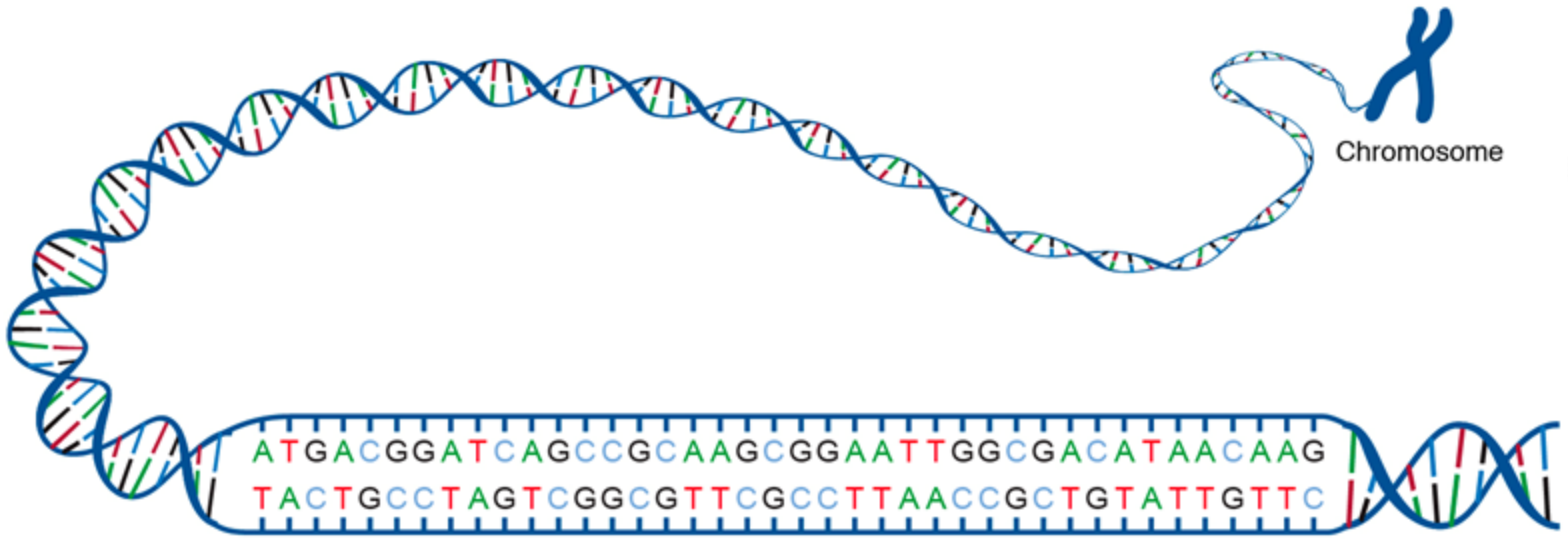
Transforming Science Learning

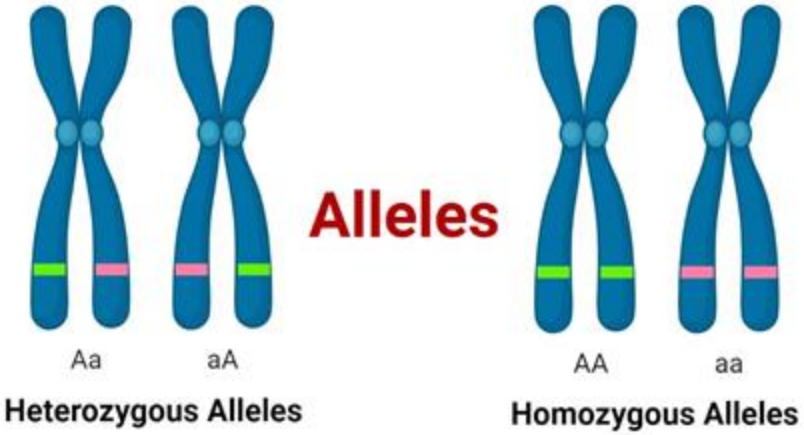
Case Study: Sickle Cell Anemia

Constructing Punnett Squares

	A	a
A	AA	Aa
a	Aa	aa



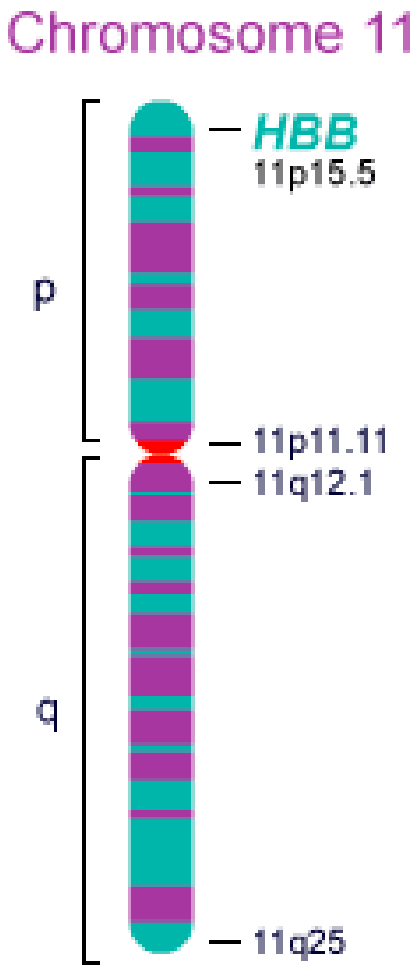


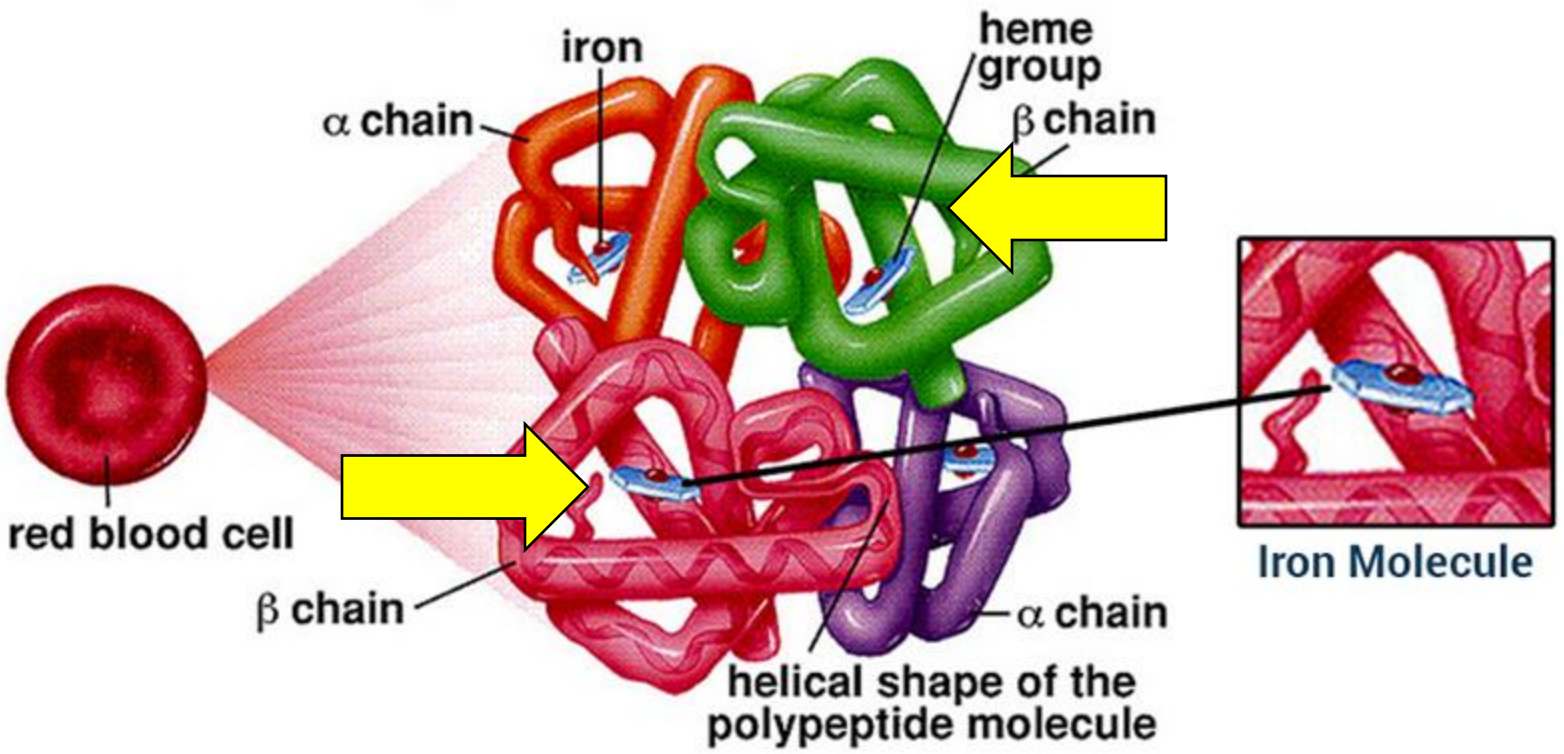



```
ACAAGGGAC TGGGGCTTGA AGAGA
GAGAAAGAT ATTTATCTTC ATGGT
GCAAAGAAA CCAAGGAGCA AGGAG
ataatacac acacatgcac aaaca
cgccctctt ctctttgctc aggt
ACGATCCAG GCCGGTGCGG ATGAC
CCCAGACTC CAGACCACGG TAGAT
AATGGCCTG AGACCACAGA AACTC
CTGCCCAGG GCCACTCACT TTAGA
```

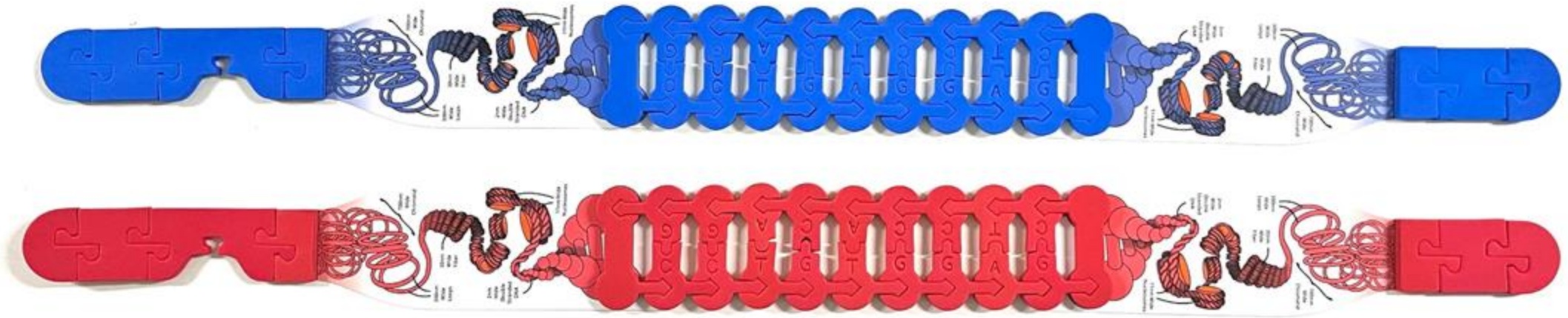
Allele ⇔ Chromosome ⇔ DNA Sequence

HBB Gene → Beta-globin protein





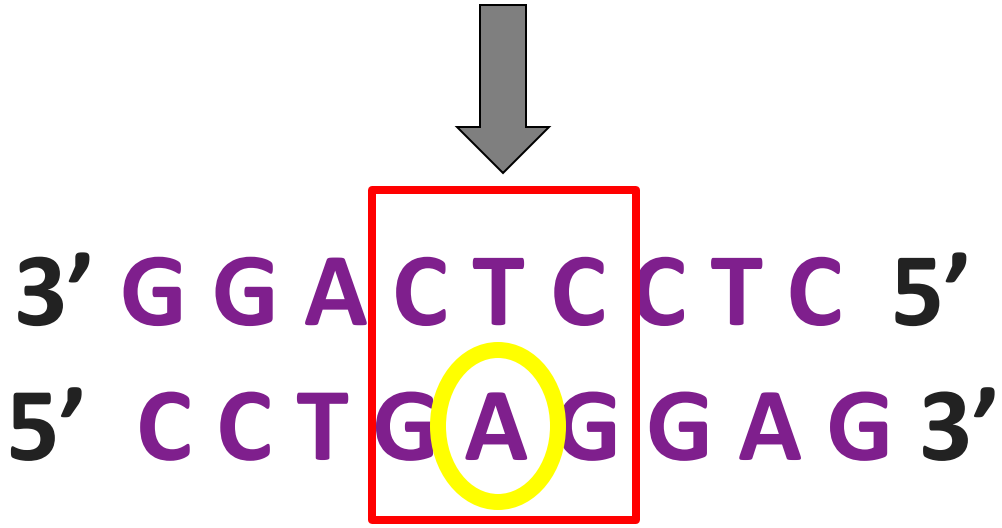
Let's return to our original model of a chromosome.

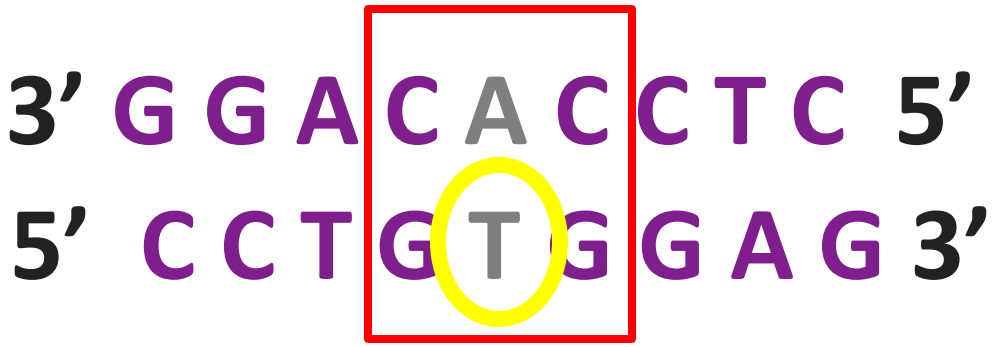


The DNA sequence shown is a portion of the *HBB* gene.

What would happen if there was a mutation?

Let's examine a point mutation in Codon 6 of the HBB gene

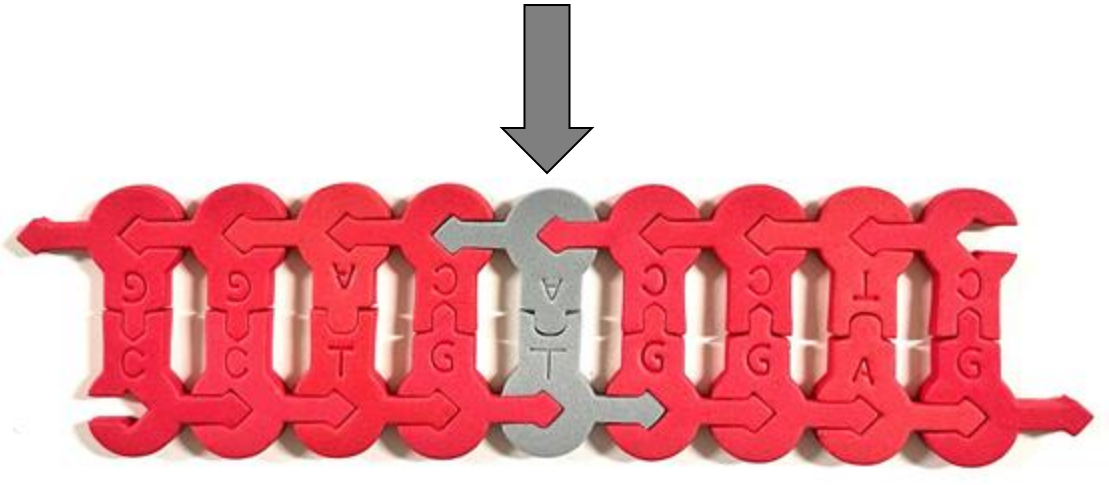




GAG → GTG

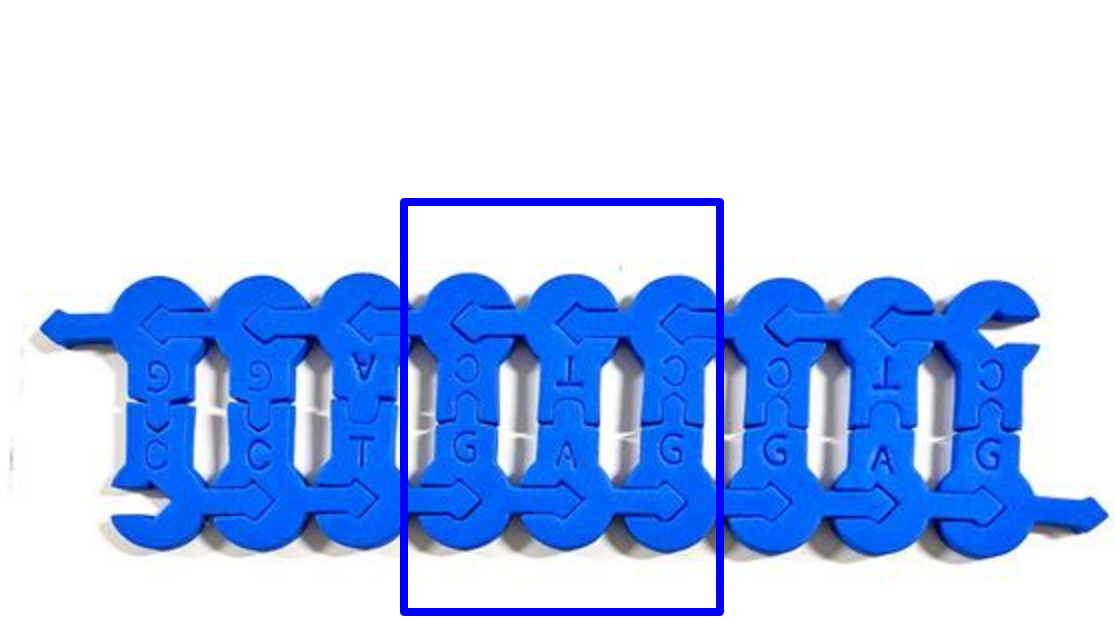
The model of the DNA sequence can be used to show a point mutation

Paternal Chromosome

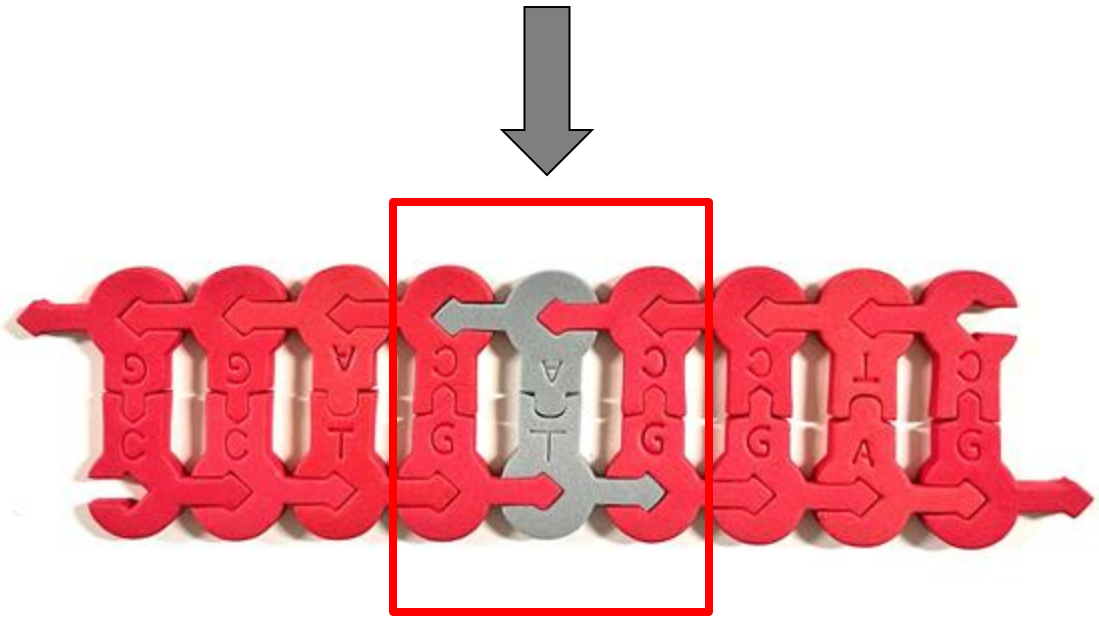


Maternal Chromosome

Let's focus on *Codon 6*.



Paternal Chromosome



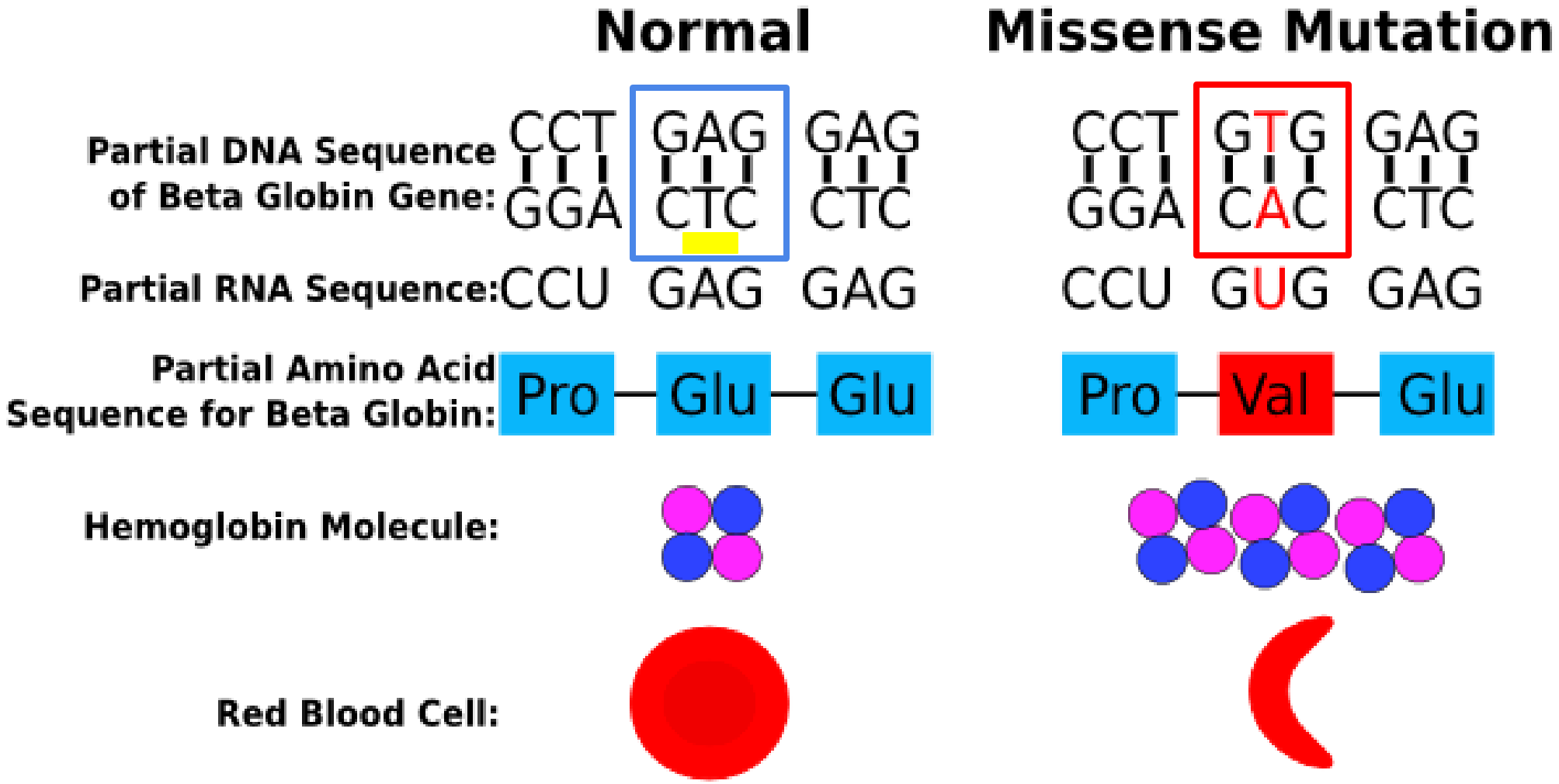
Maternal Chromosome

Let's focus on *Codon 6*.

Paternal Chromosome

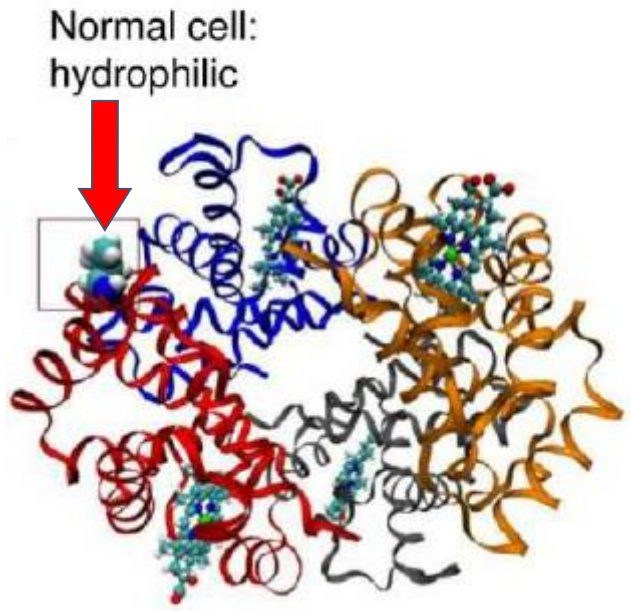
Maternal Chromosome

Mutation = Change in DNA sequence

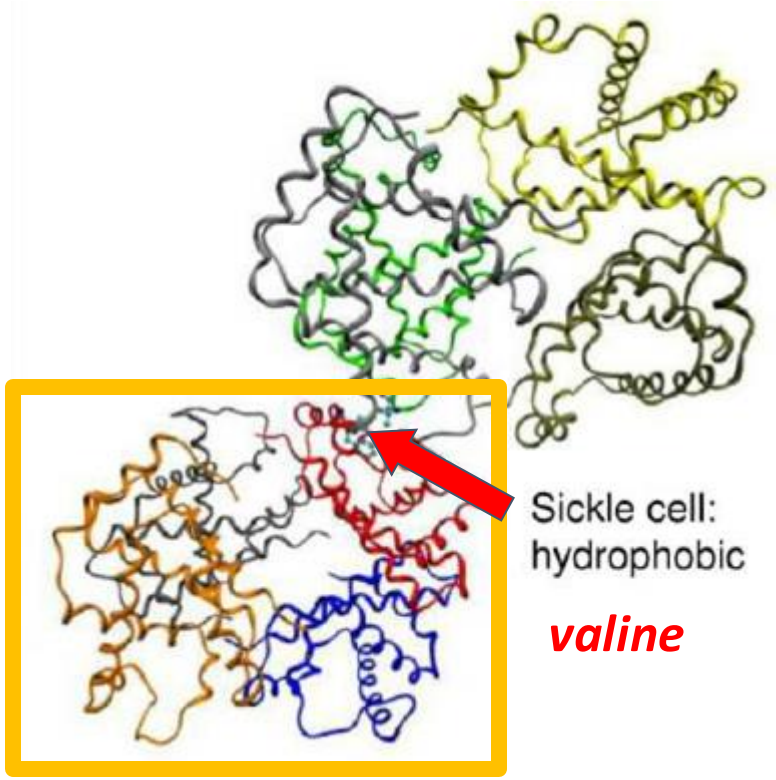


Normal Hemoglobin

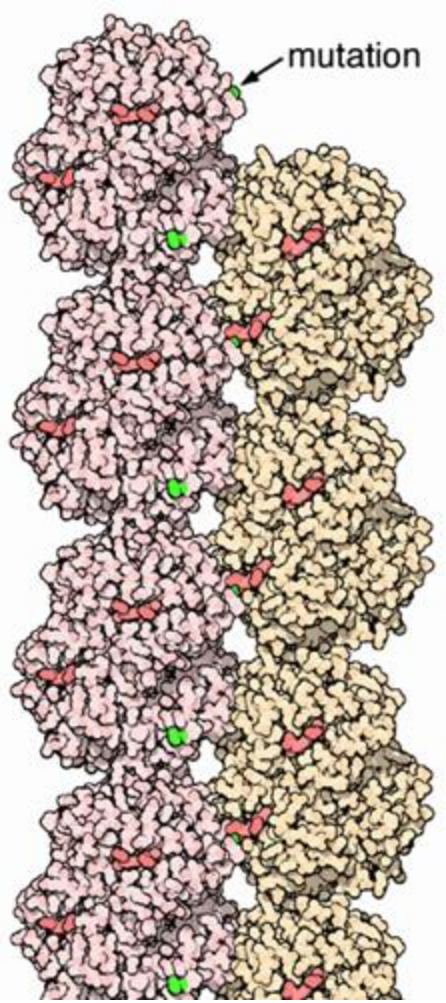
glutamic acid

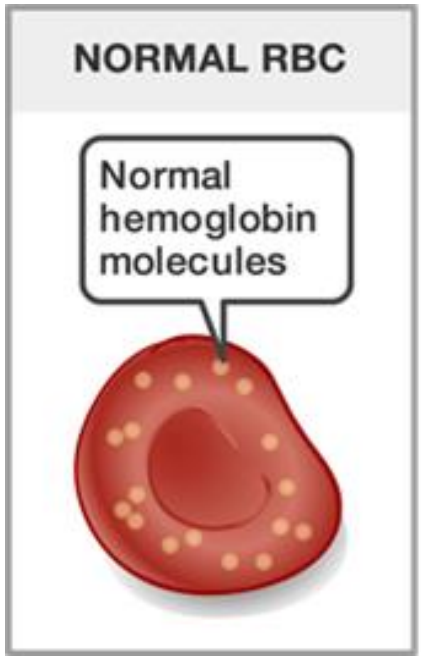


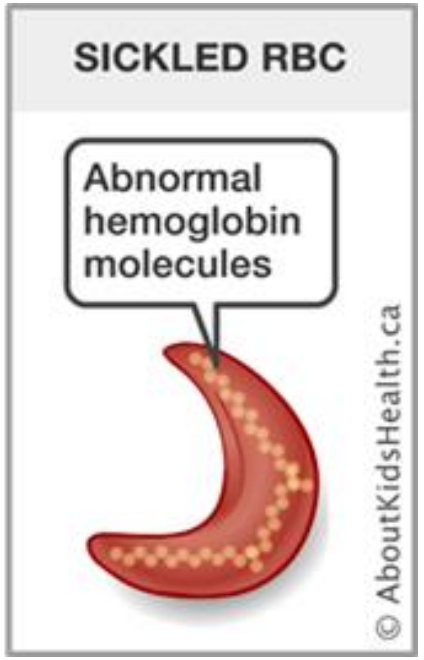
Abnormal Hemoglobin



valine







Normal capillary

Sickle Cell Anemia

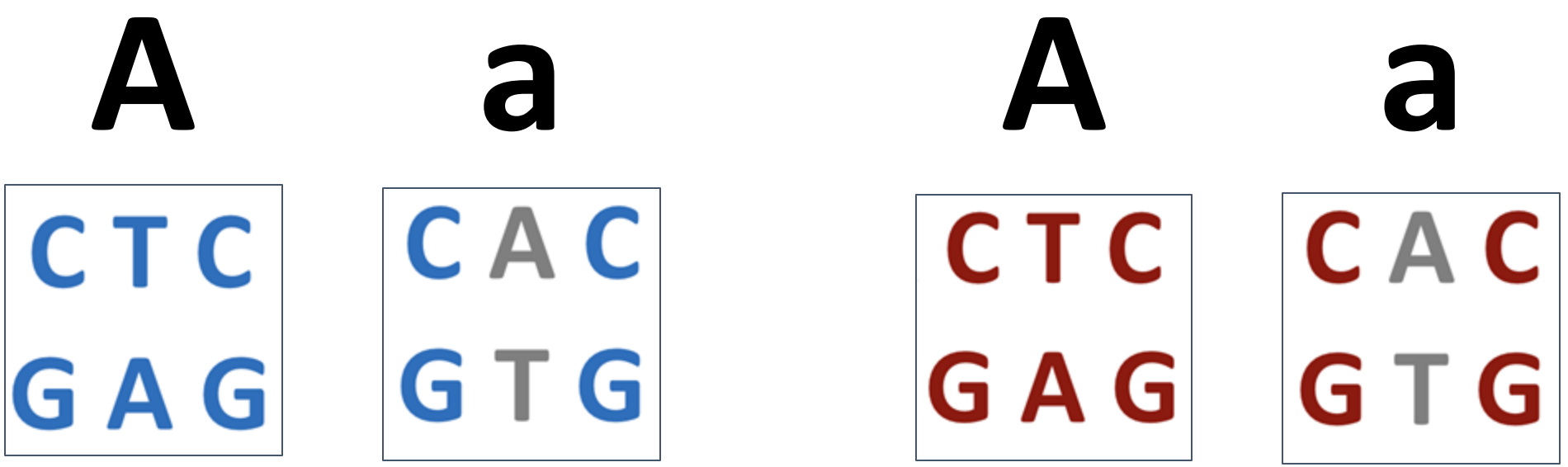
Normal Hemoglobin

Abnormal Hemoglobin

Point mutations (on autosomes) can be found on paternal or maternal chromosomes

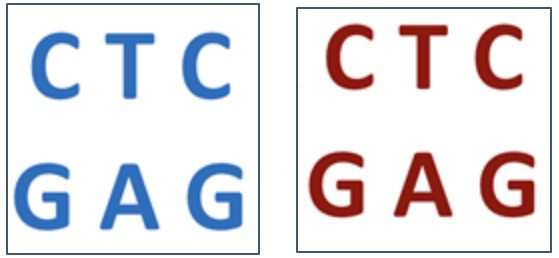
Paternal Chromosome **Maternal Chromosome**

Allele Designations



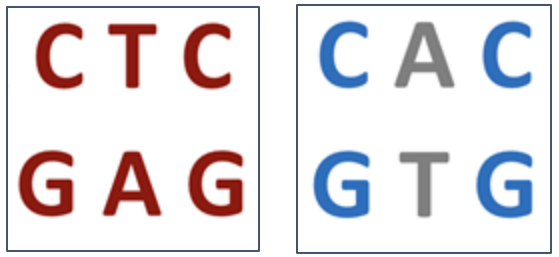
Possible Allele Combinations

AA

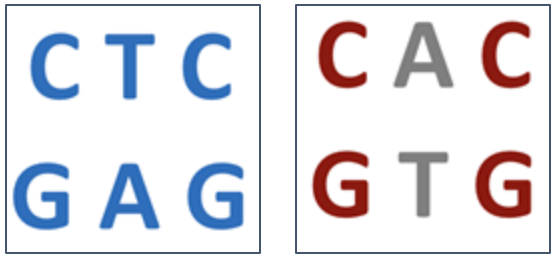


Normal (not affected by sickle cell disease)

Aa

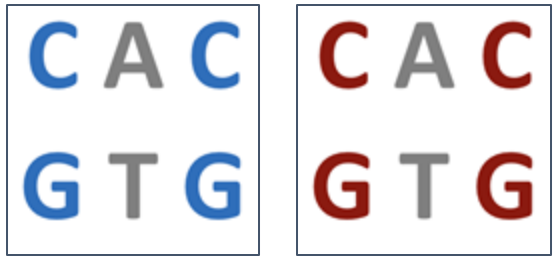


or



Carrier (sickle cell trait)

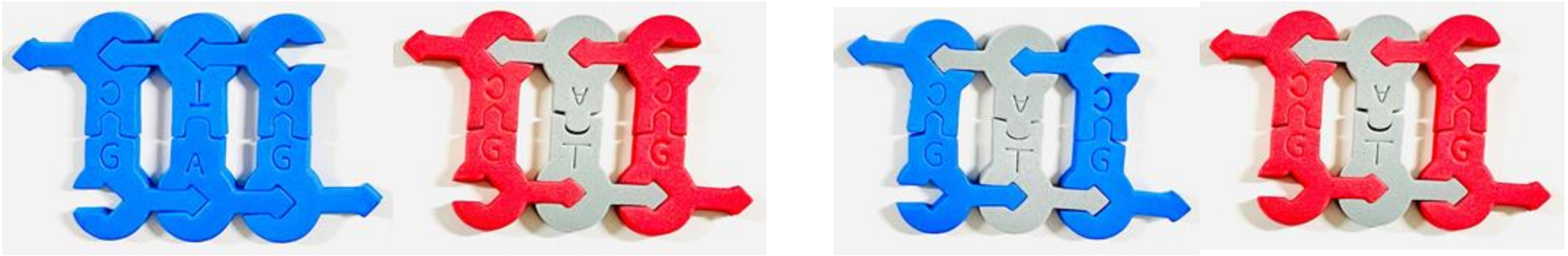
aa



Affected with sickle cell disease

Model a cross between an unaffected “carrier” parent (heterozygous) with an affected parent (homozygous for sickle cell disease) using the mini DNA sequences

Aa x aa



Aa x aa

What are the possible combinations of alleles (DNA sequences) that their children could inherit?

 (Aa)	 (Aa)
 (aa)	 (aa)

What are other ways in which these models could be used to help students make connections to the molecular world?

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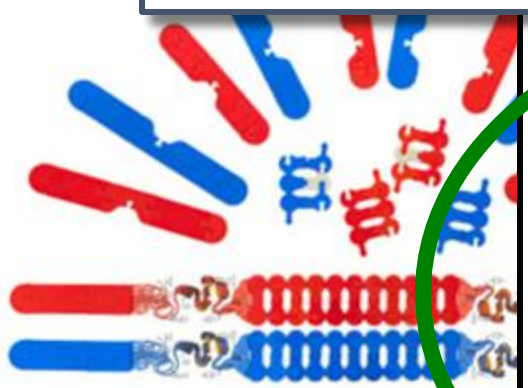

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