



# Antibody Coloring Activity

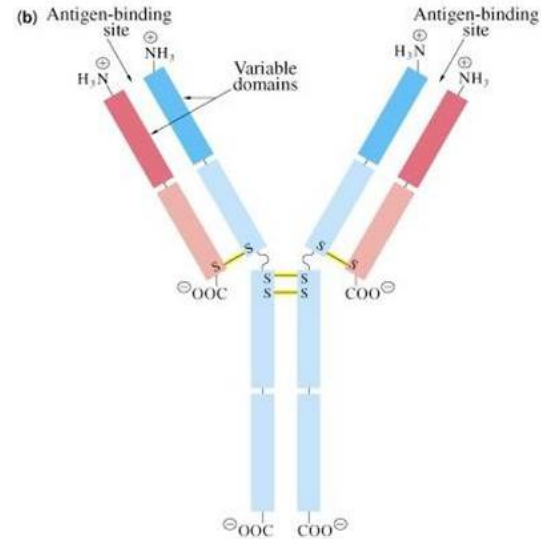
This lesson was adapted from the original created by the Science Education Partnership at Fred Hutchinson Cancer Research Center, Seattle, WA

Figures created by Tracey Kwong, MCB Student, Summer, 2007

Adapted from *Biological Science*, 2nd edition, 2004, by Scott Freeman (Prentice Hall)

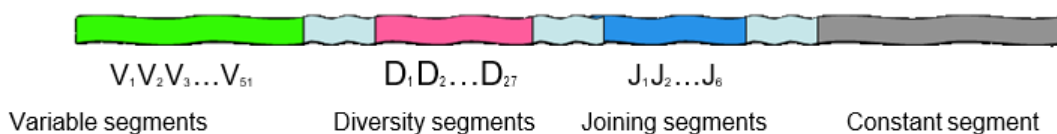
## Important Concepts:

- Antibodies are made of 2 heavy chain polypeptides (blue in the diagram) and 2 light chain polypeptides (red in the diagram). Each chain is a polymer of amino acids.
- Disulfide bonds (S-S bonds between cysteine residues) hold the 4 chains together. Two disulfide bonds connect the heavy chains together, while one disulfide bond connects each light chain to the nearest heavy chain.
- The antibody takes on a Y-shape when all 4 chains interact.
- The trunk of the "Y" makes up the constant region of the antibody and is specific to each species. The arms of the "Y" on the antibody make up the variable region and form a specific shape that recognizes and binds to one unique epitope (specific region of an antigen).
- Each mature B cell produces antibodies that recognize only one target. There are only about 21,000 human genes total, so how are millions of different antibodies created when there aren't millions of different genes?
- Our B cells create tremendous variety in antibody structure from three genes (two that code for light chains, one that codes for heavy chains) using a special mechanism called VDJ recombination. Remember that each gene has 2 alleles.
- When a B cell is immature, the heavy chain gene contains multiple V segments, D segments, and J segments, and the light chain gene contains multiple V and J segments.
- As immature B cells mature, one V segment, one D segment, and one J segment are selected at random and recombined into a revised, shorter heavy chain gene. A similar process occurs in the light chain gene. (There is no D segment is present in the light chain genes).
- In mature B cells, these shorter genes will provide the instructions for producing the heavy and light chain polypeptides that comprise the structure of the unique antibody.



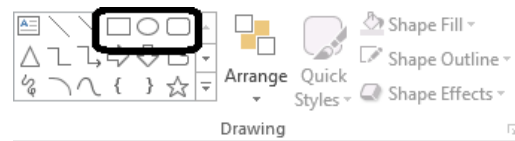
From: <http://chemistry.umeche.maine.edu/CHY431/Antibody.jpg>

Heavy chain DNA in immature B cell:



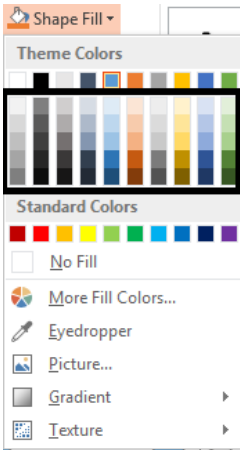
# Instructions:

1(a)

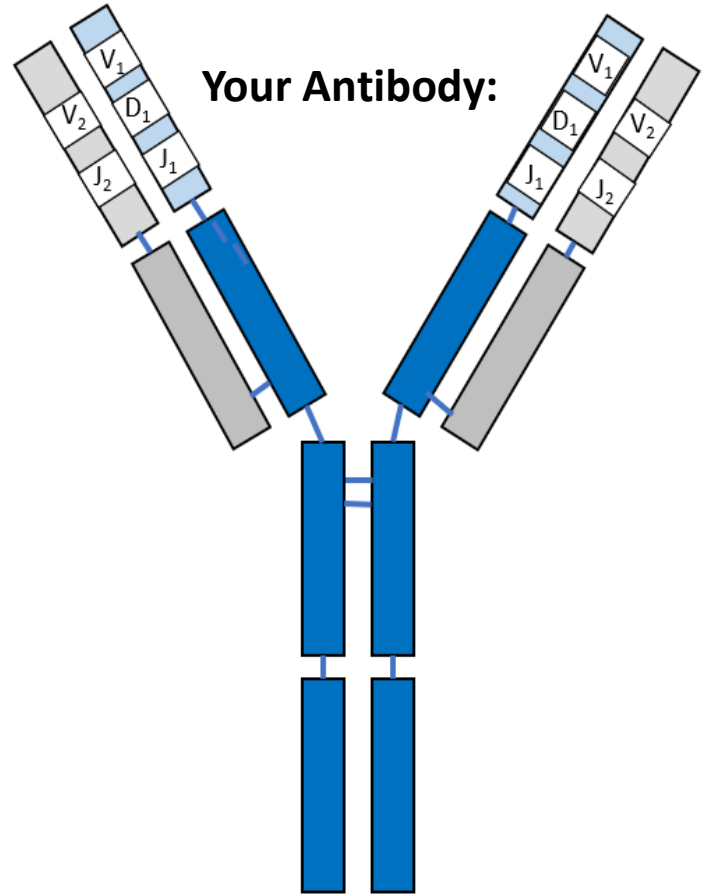
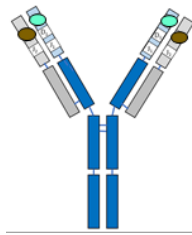


1. (a) From the "Drawing" menu, select a rectangle, circle or square feature and draw your shape over the two V1 boxes on the heavy chains. (b) Click on your shape, and, from the "Shape Fill" menu, chose one of the 50 outlined colors and shade in the V1 shapes. (c) Make new boxes for the V2 boxes, chose another color, and color in the V2 shapes.

1(b)

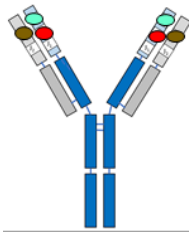


**Step 1 Example:**



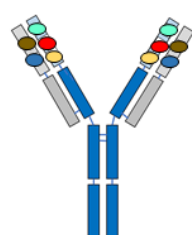
2. From the "Drawing" menu, select a shape as you did in Step 1(a), draw your shapes over the two D choose a new color from the "Shape Fill" menu in these boxes, and fill them with this new color you did in Step 1(b).

**Step 2 Example:**



3. (a) From the "Drawing" menu, select a shape as you did in Step 1(a), draw your shapes over the two J1 boxes, choose a new color from the "Shape Fill" menu to fill in these boxes, and fill them with this new color as you did in Step 1(b). (b) Repeat this process to add new colored boxes to the J2 boxes.

**Step 3 Example:**



4. Save your document so that you can show your antibody to the rest of your class!

## Review & Discussion:

1. Do you think there are any students who have the exact same coloring on their model? Explain why or why not.

2. Using the color for each region, how many varieties of antibody might you be able to create in this model?

Heavy chain: (50 V segments) X (50 D segments) X (50 J segments) = \_\_\_\_\_ possible combinations

Light chain: (50 V segments) X (50 J segments) = \_\_\_\_\_ possible combinations

(\_\_\_\_\_ possible heavy chains) X (\_\_\_\_\_ possible light chains) = \_\_\_\_\_ possible antibody variations

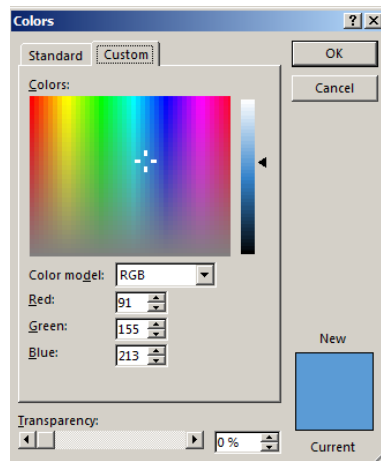
3. Now how about the real thing?

Heavy chain: (51 V)(25 D)(6 J) = \_\_\_\_\_ possible combinations

Light chains: (40 V)(5 J) + (31V)(4 J) = \_\_\_\_\_ possible combinations

(\_\_\_\_\_ possible heavy chains) X (\_\_\_\_\_ possible light) = \_\_\_\_\_ possible combinations

BUT WAIT!! Because of additional recombination events and mutations during mitosis, the actual number of possible antibody variations is potentially much greater than  $1 \times 10^8$ . Because of these unique types of DNA recombination, it's a bit more like selecting your color palette from this Custom Color menu image below.



For more details about DNA recombination and Immunology, see G.J.V Nossel's 2003 article in *Nature*, "The Double Helix and Immunology," available at:

<https://www.nature.com/articles/nature01409>