

Antibody Coloring Activity



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**SCIENCE
EDUCATION
PARTNERSHIP**

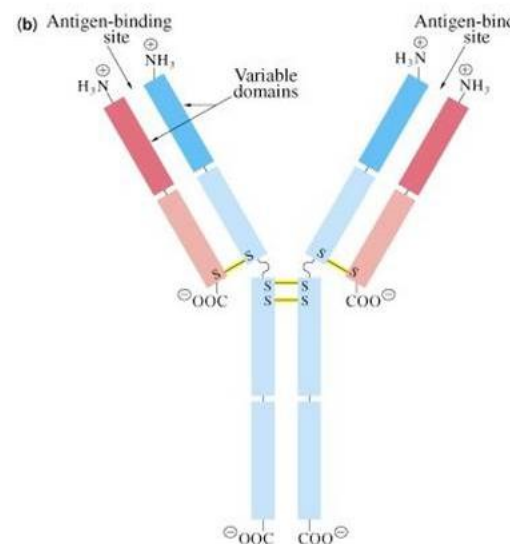
This lesson was adapted from the original created by the Science Education Partnership at Fred Hutchinson Cancer Research Center, Seattle, WA

Figures created by Tracey Kwong, MCB Student Summer 2007

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

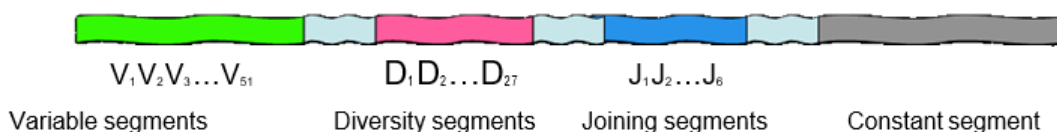
Important Concepts

- 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) using a special mechanism called VDJ recombination.
- 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 (no D segment is present in this chain).
- In mature B cells these shorter genes will provide the instructions for producing the heavy and light chain polypeptides that compose the structure of the unique antibody.



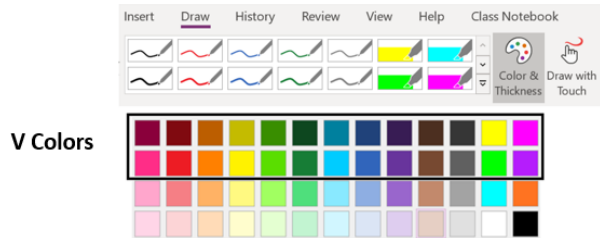
From: <http://chemistry.umeche.maine.edu/CHY431/Antibody.jpg>

Heavy chain DNA in immature B cell:

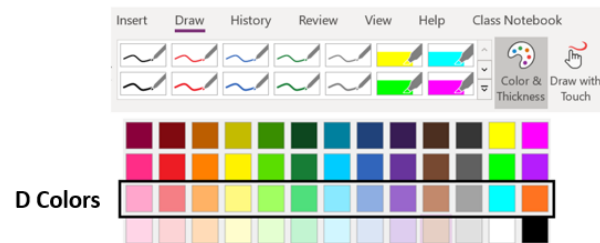


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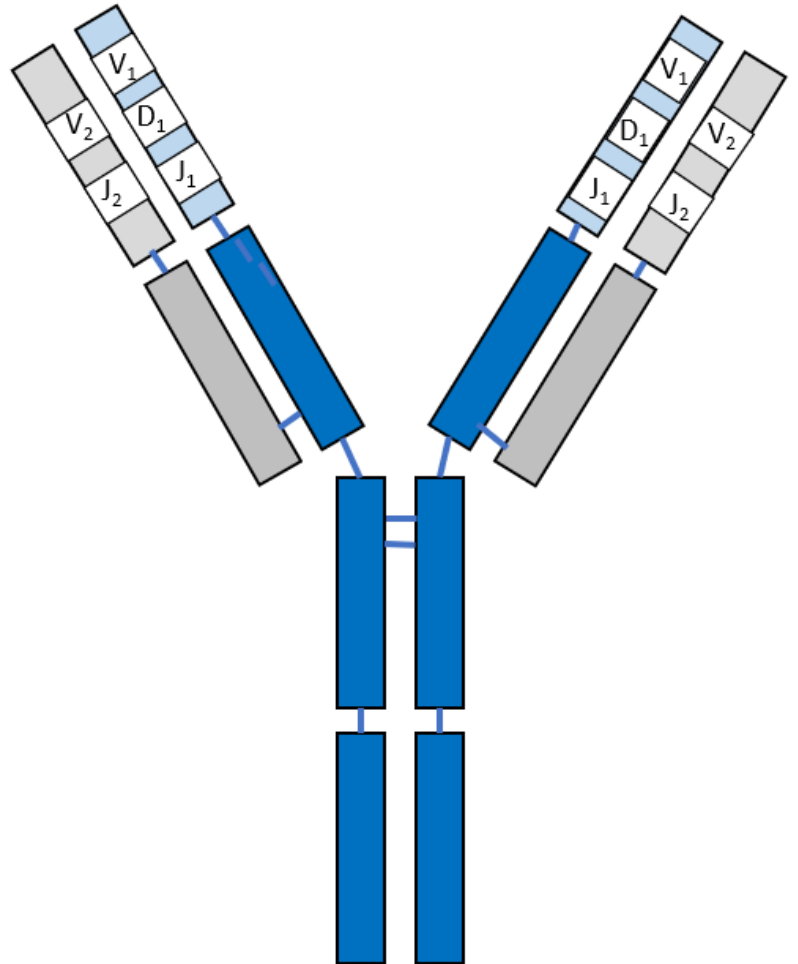
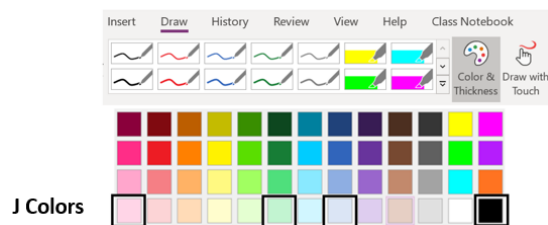
1. From the "Draw" menu, select "Color and Thickness" to see the color palette. Chose one of the 26 outlined colors and shade in the V1 boxes. Chose another and color in the V2 boxes.



2. From the color palette, chose one of the 13 outlined colors and color in the D1 boxes.



3. From the color palette, chose one of the four outlined colors and fill in the J1 boxes. Chose another and fill in the J2 boxes.



The Discussion

1. Do you think there any students who have the exact same coloring on their model?
2. Using the color for each region, how many varieties of antibody might you be able to create in this model?
 - a. Heavy chain: (26 V segments) X (13 D segments) X (4 J segments) =
possible combinations
 - b. Light chain: (26 V segments) X (13 J segments) = __possible combinations
 - c. (____possible heavy chains) X (__possible light chains) =
possible antibody variations
3. Now how about the real thing?
 - a. Heavy chain: (51 V)(25 D)(6 J) = __possible combinations
 - b. Light chains: (40 V)(5 J) + (31V)(4 J) = __possible combinations
 - c. (____possible heavy chains) X (__possible light) =
possible combinations
 - d. BUT WAIT!! Because of additional recombination events and mutations during mitosis, the actual number of possible antibody variations is potentially much greater than 1×10^8 (see the Nature Article: The Double Helix and Immunology).