

## 7.013 Recitation 15 - 2013

### Summary of Lectures 24 & 25

The immune system protects the body from foreign entities that have invaded it, such as bacteria and viruses. It does so by making proteins called antibodies, which recognize and direct an attack against foreign entities, which are often called antigens. A person's body produces billions of different antibodies. Many of these randomly generated antibodies have the potential to recognize proteins that are made in one's own body. The immune system however has a way of distinguishing antibodies that act against "self" antigens from that against "non-self / foreign" antigens. It does so by destroying or preventing the proliferation of any antibody-producing cell that recognizes a self-made antigen.

Our bodies make billions of different antibodies. These are proteins and thus are encoded by genes. However, our genomes contain less than 30,000 genes. So it is not possible that we would have a different gene to encode for each different antibody that we generate. The explanation for this is that there is a cluster of segments of genes (called V, D, and J segments) in the section of the genome that encodes antibodies. Every antibody-producing cell rearranges these DNA segments to join one V segment to one D segment to one J segment, thereby creating one gene that makes one antibody. Every different antibody-producing cell rearranges this cluster of DNA segments differently. Thus all antibody-producing cells contain only one gene that encodes an antibody, but every cell contains a different arrangement of that gene thus leading to antibody diversity. Other than cells of immune system, every cell in your body contains the exact same DNA as every other cell because no such rearrangement occurs.

The immune system provides humoral and innate immunity. There are three important cell types that play critical roles in the humoral arm of the immune system – phagocytic cells, B cells and helper T cells ( $T_H$ ). When a phagocytic cell encounters a foreign particle in the body, it eats that particle and displays pieces of the particle on its surface using the cell-surface display protein MHC class II. A  $T_H$  cell has a protein on its cell surface called T cell receptor (TCR). Every  $T_H$  cell has a different TCR that recognizes a different antigen (because every  $T_H$  cell rearranges the TCR gene in the genome differently, in a mechanism similar to VDJ joining). If a  $T_H$  cell encounters a phagocytic cell displaying the antigen recognized by its own TCR, then that  $T_H$  cell undergoes clonal expansion. The many  $T_H$  cells of this kind then go searching for a B cell that recognizes the same antigen as that  $T_H$  cell. If the  $T_H$  cells find the right B cell, then that B cell undergoes a clonal expansion. These B cells make secreted antibody that recognizes and attack the foreign antigen.

The immune system displays memory; we know this because the second time the immune system encounters an antigen, the response of B cells and T cells is faster and stronger. The principle behind vaccination is to expose an organism to some of the antigens of a harmful foreign particle that will spark the immune system's memory in case the actual entire foreign particle ever invades that organism.

Another type of immunity is the innate immune response. This response is however not antigen – specific and does not generate immune memory. This commences immediately upon pathogen entry and involves multiple cell types such as macrophages and mast cells. If these cells cannot rapidly eliminate pathogen, inflammation is induced with the synthesis of cytokines and acute phase proteins.

### **Questions**

1. Viral infections can be treated using anti-viral drugs, or they can be prevented in the first place through the use of vaccines. Some vaccines are just injections of viral particles that have been inactivated in some way (such as extreme heat). Other vaccines are injections of a single viral protein that has been purified and produced using recombinant DNA techniques. How does a vaccine work?
2. Each one of your gametes contains  $3 \times 10^9$  base pairs of DNA in its nucleus. How many

base pairs of DNA are contained within:

- a) Each nerve cell?
- b) Each antibody-producing white blood cell?
- c) Each red blood cell?

3. The cellular arm of the immune system employs cytotoxic T lymphocytes (T<sub>c</sub>) and natural killer cells. The T<sub>c</sub> cells can recognize the viral infected body cells.

- a) What proteins are involved in the presentation of the antigen to the T<sub>c</sub> lymphocytes?
- b) Explain why the T<sub>c</sub> lymphocytes do not recognize an infected cell if the virus is latent i.e. viral capsid protein does not occur.

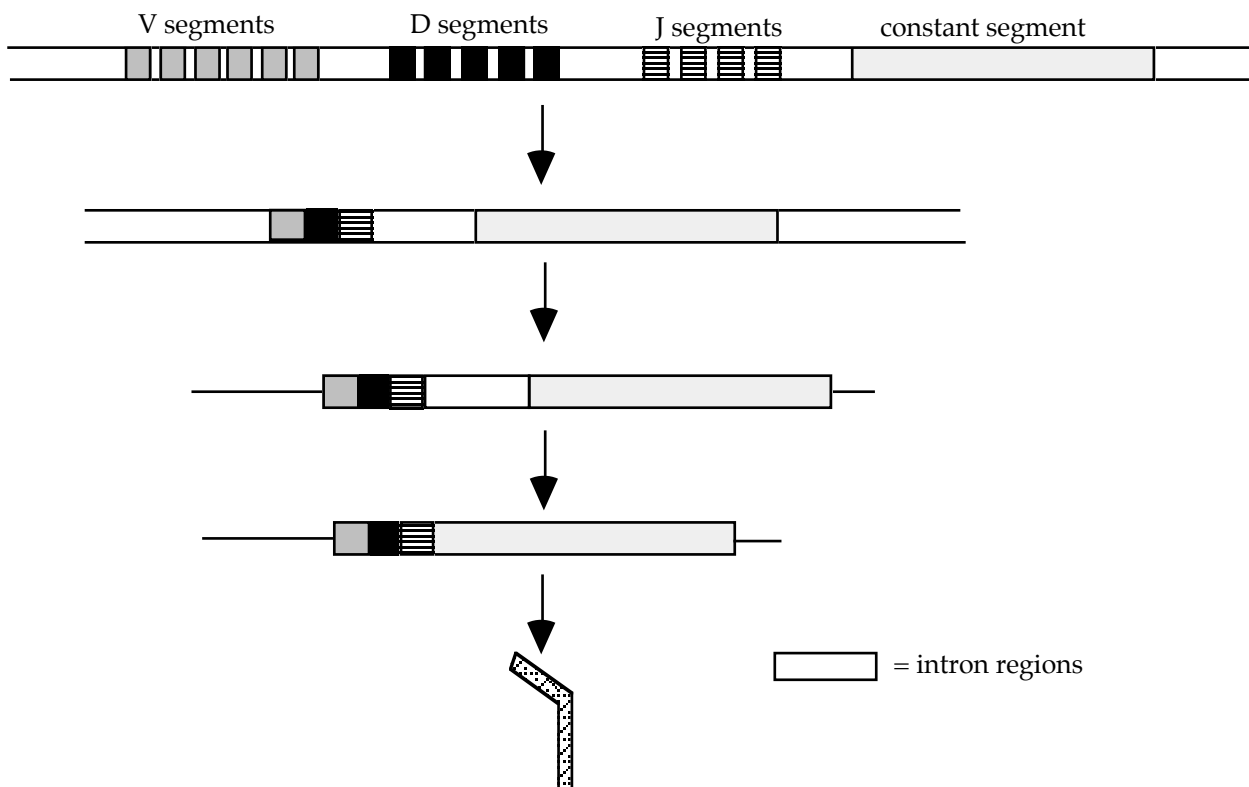
4. Shown below is a schematic of the production of a heavy chain polypeptide for an antibody. At the top is the chromosomal arrangement found in an immature B cell, at the bottom is shown the heavy chain polypeptide.

i. Label the process indicated by each arrow. Choose the one best option for each from: *homologous recombination, transcription, translation, translocation, ligation, DNA rearrangement, splicing*

ii. Indicate on the diagram below where you would expect to find each of the following components:

*Promoter (\*), Transcriptional terminator (1), start codon (2), stop codon (3)*

iii. Indicate on the diagram below the variable and the constant region of the heavy chain polypeptide and the N and C terminus of this polypeptide.



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