

MCB 4211; BASIC IMMUNOLOGY

FALL 2013

Instructor: Michael Lynes, Ph.D. phone: 486-4350; email: michael.lynes@uconn.edu

Office: Biological Sciences/Physics (BSP) room 308

Office hours: *No scheduled hours.* I am in my office by about 8:15AM, and usually stay until about 6. Drop by my office, phone, or email to make an appointment.

Class meetings Tuesday, Thursday room: BSP 131 (2-3:15 pm)

Teaching Assistants: Kathryn Pietrosimone (kathryn.pietrosimone@uconn.edu) and Jamie Rice (james.rice@uconn.edu), and Sadikshya (Sadie) Bhandari (sadikshya.bhandari@gmail.com) phone: 486-3648 Office: BSP 317/318

Course website: http://lynes.uconn.edu/Lynes_Lab/MCB4211.html

Goals of this course: The course draws together a multitude of different fundamental scientific fields that form the foundation for our understanding of how the immune system functions to distinguish "self" from "non-self". From this foundation, we will proceed to consider the variety of ways in which the immune system can fail to protect an organism, thus leading to a multitude of disease processes. We will also discuss the role the immune system can itself play in the initiation of disease and the range of autoimmune and neoplastic diseases that are influenced by human activities. Finally, we will discuss intentional manipulations of the immune system that can influence the direction of these diseases.

The course is specifically oriented to address the issue of *how* we know what we know about the immune system. Emphasis will be placed on specific experiments and assays that are important to our understanding of the immune system.

Recommended approach to studying course material

1. *Skim over each assigned chapter before class*, and look at figures in chapter.
2. *Take notes in class*; copy notes over that night after class to ensure you understand what you wrote. If you have trouble taking good notes, consider bringing a tape recorder to supplement your notes.
3. Following each class, *read assigned chapter for comprehension* (don't fall behind!).
4. Be certain to *read primary literature assignments* before the assigned date! We discuss these papers in class, and this material will be included in the examinations.

Administrative notes

1. Please turn off your cell phone *before* class, do *not* bring cell phones, blackberry devices, pagers or other electronic devices to the examinations (you may leave your bookbags with these inactivated items in the front of the classroom during the exam if necessary).
2. Randomized seating will be assigned at the beginning of each examination.

Grades

Examinations will focus on material presented in class, and the supplemental assigned readings. The final grade will be based on two **quizzes** (5% each), two **hour-long exams** (25 % each), and the **final examination** grade (40%). Exam coverage is listed in the class schedule below.

Statement on Academic Integrity

“A fundamental tenet of all educational institutions is academic honesty; academic work depends upon respect for and acknowledgement of the research and ideas of others. Misrepresenting someone else's work as ones own is a serious offense in any academic setting and it will not be condoned. Academic misconduct includes, but is not limited to, providing or receiving assistance in a manner not authorized by the instructor in the creation of work to be submitted for academic evaluation (e.g. papers, projects, and examinations); any attempt to influence improperly (e.g. bribery, threats) any member of

the faculty, staff, or administration of the University in any matter pertaining to academics or research; presenting, as one's own, the ideas or words of another for academic evaluation; doing unauthorized academic work for which another person will receive credit or be evaluated; and presenting the same or substantially the same papers or projects in two or more courses without the explicit permission of the instructors involved. A student who knowingly assists another student in committing an act of academic misconduct shall be equally accountable for the violation, and shall be subject to the sanctions and other remedies described in The Student Code.” (taken from the UCONN student handbook.)

***** added at the request of the Office of Student Services and Advocacy*****

Students are required to be available for their exam during the stated time. If you have a conflict with this time you must visit the Office of Student Services and Advocacy to discuss the possibility of rescheduling this exam.

Please note that vacations, previously purchased tickets or reservations, graduations, social events, misreading the exam schedule and over-sleeping are not viable excuses for missing a final exam. If you think that your situation warrants permission to reschedule, please contact the Office of Student Services and Advocacy with any questions. Thank you in advance for your cooperation.

TEXTBOOK and other READINGS

The newest version of "Janeway's Immunobiology" by Kenneth Murphy, **8th edition** has a publication date of July 2011, and is published by Taylor and Francis/Garland Scientific. The ISBN for the paperback version of the text is 978-0-8153-4243-4. We have used this textbook before, so there should be used copies available.

There are also electronic versions of the textbook available for both computers and e-readers. These can be purchased at reduced cost with either unlimited access, or access for 1 year or 1 semester. The e-book version will be available for purchase or rental from the VitalSource website (<http://store.vitalsource.com>). You will have to register as a Vitalsource user with an email and password, and then find the textbook link (<http://store.vitalsource.com/show/978-1-1366-6521-9>). From a mobile device, you will need to load the vitalsource app to be able to read the book on your e-reader, but downloading it from the app is straightforward. At present, the .vbk file format is only compatible with computers, iphones, ipods and ipads. Vitalsource.com says that Kindle, Nook and other e-reader compatibility is coming, but is not available at present.

The announced pricing for the 8th edition:

Paperback ~\$129.00 (list) and is also available from online bookstores such as Amazon

The various e-book options for Janeway's Immunobiology 8E are now compatible with most e-readers and computers. There are several options for ebook rental or purchase, and two different formats. The standard format is a flat pdf file with limited manipulations (e.g. highlighting), and a second format that is more interactive (called "inkling"). I do not have experience yet with the interactive format.

eBook purchase: \$95.00 (30% off list price)

1 year e-rental: \$81.00 (40% off list price)

180 day e-rental: \$68.00 (50% off list price)

The paperback will be available from the UCONN Co-op and other vendors, but e-book purchases and rentals are made independently through the publisher's website. To purchase or rent the e-book at the VitalSource store go to <http://store.vitalsource.com/show/978-1-1366-6521-9>

Statement on textbook use: the text is a required component of the course, and specific readings are noted in the semester schedule below. Because all exam questions will be taken from the lecture notes, it may appear that the text is superfluous. However, students are strongly encouraged to follow the

recommended approach to studying the class material. This includes reading the relevant sections of the text. Much like learning a new language, the study of immunology requires a familiarity with the technical language of the immune system, and with the ways in which concepts interrelate. The text is organized to emphasize these relationships.

Primary literature readings: There are six readings from the primary scientific literature that are required during the semester. You will see them noted on the days that they will be discussed. Read these papers in advance of the class. To find the text of the paper, go to the MCB 4211 website for a copy of the syllabus and insert the weblink into your browser window, or upload it from the e-journal site at the UCONN library website (<http://tk8nj5xn8a.search.serialssolutions.com/>). Note, for some journals, you need to set up a vpn link if you want to access the journals from off campus. You can do that at https://vpn.uconn.edu/dana-na/auth/url_default/welcome.cgi.

Other links: In some places in the syllabus, there are additional interesting readings that are related to a specific lecture topic. These other readings or videos are optional, but often both informative and entertaining.

Supplemental Honors (section 002) reading

The honors section of the course will focus on themes raised by “The immortal life of Henrietta Lacks” by Rebecca Skloot (ISBN 1400052173 Random House Publishing.) This book can also be purchased as a paperback or as an ebook from a variety of vendors including Amazon, Barnes and Noble, Borders, etc. In addition to this short book, there will be assigned readings from the primary literature.

Other interesting information related to this interesting book can be found at the author's website <http://rebeccaskloot.com/the-immortal-life/>

Semester Schedule

<u>Date</u>	<u>Topic</u>	<u>Readings</u>
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8/27 Introduction, overview of course

A. Organization of the course

1. content: lecture with associated primary literature readings (references are noted in outline)
2. additional resource materials: assigned text readings/note additional textbook features, websites
3. course format: lectures and discussions during class: ***feel free to ask questions in class; you may tape the lectures if you wish.***
4. examination format and content

B. Historical roots of the study of Immunology

1. Immunology is a relatively young science compared to botany, zoology, physics, etc.
 - a. 1798 Jenner: cowpox immunization
 - b. 1891 Koch: DTH vs tuberculin Ag
 - c. 1895 Bordet: C' + Ab + bacteria = lysis
 - d. 1901 Landsteiner: ABO blood groups
 - e. 1914 Little: genetic theory of tumor transplantation
 - f. 1936 Gorer: identification of MHC antigens
 - g. 1939 Kabat and Tselius: Antibodies as gamma globulins

C. At its most basic: simple concept of immunological system activation

1. Signal molecule interaction with receptor molecule leading to information processing that produces either tolerance or some response
 2. signal molecule = antigen; smallest unit that is *recognized* as non-self
 3. Characteristics of the immune response that may be present (but not always)
 - a. specificity
 - b. memory
- D. Current trends in immunological research
1. manipulation of the response to disease for therapeutic benefit
 - a. AIDS
 - b. cancer
 - c. autoimmunity
 - d. tissue transplantation; stem cell biology
 2. antibodies as enzymes (“abzymes”)
 3. antibodies as probes of biochemical/cellular structure and as probes of biomarker signatures
 4. psychoneuroimmunology
 5. cytokine immunotherapies
 6. xenogeneic transplants of humanized tissues /stem cell transplants of autologous tissues
 7. diseases with newly recognized immunological components
 8. therapeutic manipulations of disease with novel antibody constructs (single chain, minibodies, etc.)
- E. Lynes laboratory research interests (<http://web.uconn.edu/lyneslab/>)
1. mechanisms of immunotoxicity & role of metallothionein in stress-mediated immunomodulation
 - a. MT and immune regulation
 - b. MT and rheumatoid arthritis, inflammatory bowel disease
 - c. MT and infection
 - d. the role of bacterial MT (SmtA) and pathogenesis
 2. automated measurements of chemotaxis
 3. Grating-coupled surface plasmon resonance imaging (GCSPRI) and grating coupled surface plasmon coupled emission (GCSPCE) cell and protein microarray platform applications
 - a. use of the surface plasmon resonance (SPR) microarray platform for immune characterization of arthritis and type 1 diabetes
 - b. SPR based pathogen, toxin, and toxin biosensors
 - c. Functional phenotyping in a microarray format; Cytometer on a chip, Type 1 diabetes diagnosis
 - d. vaccine assessment in human and agricultural pathogen immunizations

8/29 Macromolecules, cells, and tissues of the Immune Response

Reading: Immunobiology textbook Chapter 1

A. Cells

1. hematopoiesis
 - a. lymphoid lineage
 - b. other cells (erythroid and myeloid lineages)
2. structure/function of cells in these lineages
3. organization of cells into tissues and organs
4. lymphocyte traffic

B. Soluble components of the immune system

1. antibodies (structure/function)
2. complement (structure/function) (Other Links #2)
3. cytokines (structure/function)

9/3 The experimental system

Optional extra reading: <http://www.informatics.jax.org/silver/>

Chapter 1

- A. Experimental model systems
 - 1. phylogenetic studies: interesting immune adaptations in evolutionary contexts
 - 2. commonly used mammalian systems
 - a. mouse: mendelian inheritance and breeding manipulations(Other Links #4)
why mice?
 - b. other mammalian animal systems
 - 3. man
 - a. ethical limitations vs experimental opportunities
- B. Artificial in vivo and in vitro systems
 - 1. culture techniques: *in vitro*
 - 2. immunologically compromised animals (will discuss more fully on 11/9)
 - a. immunological mutants
 - b. radiation-induced immunodeficiency
 - 3. transgenic animals, targeted gene disruptions, chimeric animals
 - 4. "humanized" mice

9/5 Antigenicity and Immunogenicity

Reading: Immunobiology textbook Appendix I, p735-745

- A. Antigenicity vs. immunogenicity
- B. Fundamental characteristics of antigens
- C. Prototypical antigens
 - 1. mitogens as polyclonal activators
 - 2. T-dependent and T-independent antigens
 - 3. the MHC as an antigenic system

9/10 Antibodies: structure and function

Reading: Immunobiology textbook Chapter 3

- A. Immunoglobulin structure
 - 1. subunit structure
 - 2. heavy and light chains
 - 3. Immunoglobulin fragments and their uses: Fc, Fab, and F(ab')₂
- B. Antigenic determinants of immunoglobulins
 - 1. isotypes and subclasses (Other Links #1)
 - 2. idiotypes
 - 3. allotypes

9/12 Antibodies: structure and function (continued)

Reading: Primary Literature Reference #1 and Reading: Immunobiology textbook p740-756

*****sample questions that can be used to prepare for the quiz and first examination will be posted online at the course website*****answers to the questions will be posted after an interval

- A. Antibody-antigen binding: Law of Mass Action and calculation of affinity constants
 - 1. parameters of binding
 - 2. structural contributions to binding
- B. Assays of antibody binding
 - 1. Precipitation
 - 2. Agglutination
 - 3. Radioimmunoassay (RIA)

- 4. ELISA
- 5. Fluorescent immunoassay/ Flow cytometry/Fluorescence activated cell sorting (FACS)
- 6. Western immunoblot analysis
- 7. Immunohistochemistry/Immunoelectronmicroscopy
- C. Monoclonal antibodies (MAb) (Other Links #17)
 - 1. how they are made, isolated, and "humanized"
 - 2. functional differences between polyclonal antisera, monospecific sera and MAb

9/17 In class quiz #1: 10 questions, 15 minutes; covers all material through 9/13. Antibody/antigen Interactions (continued)

9/19 Sources of antibody diversity

Reading: Immunobiology textbook Chapter 4 (p143-155)

- A. Genetics of antibody synthesis (the B cell receptor)
- B. Generation of antibody diversity
 - 1. germline vs. somatic mutation
 - associational, junctional and combinatorial diversity
- C. Class (isotype) switching

9/24 Major Histocompatibility Complex (MHC)

Reading: Immunobiology textbook Chapter 3 p123-138

- A. Discovery as a transplantation antigen, and genetics
- B. Cellular expression/tissue distribution
- C. Contribution to cellular recognition (genetic restriction)
- D. Structure/function

9/26 FIRST EXAMwill cover material through 9/24.....

10/1 Cell biology of the MHC/protein biology of the MHC; antigen processing and presentation

Reading: Immunobiology textbook Chapter 5

- A. Mechanisms of antigen association with MHC molecules
 - 1. endocytic pathway (exogenous antigen)
 - 2. cytosolic pathway (endogenous antigen)
- B. Interactions of antigen/MHC with the T cell antigen receptor

10/3 T cell/antigen interactions

Reading: Immunobiology textbook Chapter 2 p 123-138, Chapter 4 p154-159 and Chapter 6, 7

- A. structure of the TcR
- B. genetics of TcR
- C. Other molecular components of the TcR
- D. Signal transduction following TcR engagement

10/8 Consequences of TcR engagement

Reading: Immunobiology textbook Chapter 7 p273-298

- A. T cell populations in the thymus and periphery
- B. T cell maturation
- C. Mechanisms of T cell activation
- D. Products of T cell activation (see soluble mediators)

10/10 Cell mediated immunity (CMI)

Reading: Immunobiology textbook Chapter 8

- A. Cytotoxicity
- B. Delayed type hypersensitivity
- C. Immunological protection conferred by CMI

10/15 Soluble mediators of immunity

Reading: Immunobiology textbook Chapter 2 p53-81 and Primary literature reading #2, and Appendix I, III

- A. Cytokines and lymphokines: structure and function
- B. Pattern recognition receptors and lymphokine receptors
- C. Complement (Other Links #2)
- D. Anti-idiotypic Immunoglobulins
- E. Selective migration
- F. Neuroendocrine regulation

10/17 Immune responses to infections agents

Reading: Immunobiology textbook Chapter 2 p 82-102, Chapter 10, Chapter 12 p 497-507

- A. Viral
- B. Bacterial
- C. Protozoan
- D. Invertebrate parasites; optional reading #1

10/22 Immune responses to infections agents (continued)

******sample questions that can be used to prepare for the quiz and second examination will be posted online at the course website*****answers to the questions will be posted after an interval*

10/24 In class quiz #2: 10 questions, 15 minutes; covers all material from 10/1 through 10/22

Manipulation of the Immune Response

Reading: Immunobiology textbook Chapter 15

- A. Vaccines (live/attenuated/killed; protein;DNA) optional readings #4 and 5
- B. Drugs
- C. Irradiation

10/29 Inappropriate immune reactions

Reading: Immunobiology textbook Chapters 13,14 and Primary Literature Reference #3 and 6

- A. hypersensitivities
- B. Immune tolerance and Autoimmune disease
 1. Animal models
 2. Human diseases and treatment
 - Genome Wide Associational Studies (GWAS) and autoimmune disease
 3. biomarkers of disease (autoantibodies as biomarkers of autism spectrum disorder)
see also optional reading #2

10/31 Inappropriate immune reactions (autoimmunity, continued)

11/5 SECOND EXAM will focus on material from 9/27 through 11/3,

and will depend on material from the first section of the course. Note that you are responsible for material in the required primary literature readings that are available on the MCB 4211 homepage and from the e-journal site at the UConn library website.

11/7 Immunodeficiencies

Reading: Immunobiology textbook Chapter 12 p 507-546

- A. Animal models for congenital syndromes
 - 1. nude
 - 2. SCID (Other Links #3)
 - 3. beige
- B. Human congenital immunodeficiencies

11/12 Immunodeficiencies (continued)

- A. Acquired causes of immunodeficiencies
 - 1. Environmental
 - 2. Drug induced
 - 3. Viral (Other Links #9)

11/14 AIDS (continued)

- 1. Etiology/viral replication cycle
- 2. symptoms/immune effects
- 3. epidemiology
- 4. current and future therapies (Other Links #6)

11/24-11/30

No class; Fall recess!

12/3 The immune response to cancer

Reading: Immunobiology textbook Chapter 15 p 672-687 and Primary Literature Reference #4

- A. Mechanisms of carcinogenesis
- B. Natural immune responses to neoplasia
- C. Immunological diagnosis of neoplastic disease
 - 1. tumor antigens
- D. Immunotherapies for neoplasia
 - 1. “magic bullets”: immune conjugates
 - a. antibody/drug conjugates
 - b. antibody/radionuclide conjugates
 - 2. anti-idiotypic antibodies
 - 3. irradiation and transplantation to reconstitute immunity
 - 4. TILs, LAKs
 - 5. Gene therapies (Other Links #8)

12/5 Transplantation Biology

Reading: Immunobiology textbook Chapter 14 p 637-648 and Primary Literature Reference #5, (Other Links #3, 7, 14)

- A. Immunological mechanisms of histo-incompatibility
- B. Manipulation of histo-incompatibility
- C. Clinical value of transplantation
- D. Value of MHC polymorphism in population responses to infection; consequences to transplant success

Overview and final comments

******sample questions that can be used to prepare for the final examination will be posted online at the course website*****answers to the questions will be posted after an interval*

12/9-12/15 FINAL EXAM PERIOD; You can find the entire preliminary exam schedule at <http://www.registrar.uconn.edu/exams.htm>

..... the final exam will emphasize material from 11/7 through 12/5, but will cover material from the entire course. Remember that you are responsible for material in the required primary literature readings as well as the material covered in class.....

Required primary literature

primary literature references from the scientific literature and their web links

1. Kohler, G. and Milstein, C., Continuous cultures of fused cells secreting antibody of predefined specificity. *Nature*, 1975. 256: p. 495-7.
<http://www.nature.com/nature/journal/v256/n5517/pdf/256495a0.pdf>
2. Rennard, B.O., et al., Chicken soup inhibits neutrophil chemotaxis in vitro. *Chest*, 2000. 118(4): p. 1150-7. <http://www.chestjournal.org/cgi/reprint/118/4/1150>
3. Youn, J., et al., Metallothionein suppresses collagen-induced arthritis via induction of TGF-beta and down-regulation of proinflammatory mediators. *Clin Exp Immunol*, 2002. 129(2): p. 232-9.
<http://www.blackwell-synergy.com/doi/full/10.1046/j.1365-2249.2002.01922.x>
4. Dolk, E., M. van der Vaart, et al. (2005). "Isolation of llama antibody fragments for prevention of dandruff by phage display in shampoo." *Appl Environ Microbiol* 71(1): 442-50.
<http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pubmed&pubmedid=15640220>
5. Sidle, H. V., A. Kreiss, M. D. Eldridge, E. Noonan, C. J. Clarke, S. Pyecroft, G. M. Woods, and K. Belov. 2007. Transmission of a fatal clonal tumor by biting occurs due to depleted MHC diversity in a threatened carnivorous marsupial. *Proc Natl Acad Sci U S A* 104:16221.
<http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1999395&blobtype=pdf>
6. Braunschweig D., Krakowiak P., Duncanson P., Boyce R., Hansen R.L., Ashwood P., Hertz-Picciotto I., Pessah I.N. and Van de Water J. (2013) Autism-specific maternal autoantibodies recognize critical proteins in developing brain *Translational Psychiatry* (2013) 3, e277;
doi:10.1038/tp.2013.50 <http://www.nature.com/tp/journal/v3/n7/pdf/tp201350a.pdf>

Optional Readings

1. hookworm mediated immune suppression and allergy/asthma treatment.
http://www.nytimes.com/2008/07/01/health/research/01prof.html?_r=3&pagewanted=1&sq&st=nyt&scp=2
2. **lack** of connection between vaccination and autism, and recent connections of autism to specific non-coding RNAs
<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0003140>
<http://the-scientist.com/2012/04/04/multiple-strikes-against-autism/>
3. autologous stem cells are rejected
 - a. http://www.nytimes.com/2011/05/14/science/14stem.html?_r=2
 - b. <http://www.nature.com/nature/journal/vnfv/ncurrent/pdf/nature10135.pdf>
4. Social/Legal issues in Genetics and Immunology

- a. Opinion: The Risk of Forgoing Vaccines
 - i. <http://the-scientist.com/2012/04/03/opinion-the-risk-of-forgoing-vaccines/>
- 5. Politics and immunology
 - a. Vaccination programs and international policy
<http://www.ibtimes.com/articles/363531/20120716/pakistan-taliban-polio-vaccinations.htm>
- 6. HIV prevention pill "Truvada"
<http://www.npr.org/blogs/health/2012/07/17/156868446/deciding-on-truvada-who-should-take-new-hiv-prevention-pill>

Some website addresses of interest to immunologists:

Immunology techniques, biological materials, and instrumentation websites

1. <http://flowcyt.cyto.purdue.edu> PUCL is the leading cytometry site since 1993
2. <http://www2.perkin-elmer.com/pa/340913/html/toc.html> {a manufacturers guide to immunoassays}
3. <http://www.bdfacs.com/home.htm> {a home page for a flow cytometer manufacturer}
4. <http://www.atcc.org/> {American Type Culture Collection; a source of cell lines and genetic resources}
5. <http://www.jax.org> {a resource of inbred mouse strains, transgenic and knockout mice}

Immunology databases

1. <http://prow.nci.nih.gov/> {a site that shows structural features of CD molecules}
2. <http://rarediseases.info.nih.gov/> {the office of rare diseases at NIH; for autoimmune diseases like Lupus, arthritis}

Genome databases

1. <http://research.jax.org/resources/index.html> {mouse genome information}
2. <http://www.ncbi.nlm.nih.gov/omim> {online mendelian inheritance in man}

Scientific journal websites

1. <http://www.cell.com/> {the journal Cell}
2. <http://journals.lww.com/jaids/pages/default.aspx> {Journal of Acquired Immune Deficiency Syndromes}
3. <http://www.jimmunol.org/>{ The Journal of Immunology}
4. <http://flowcyt.cyto.purdue.edu/flowcyt/websites/cytsites/sitesed.htm> {listing of other scientific journal websites}

Scientific funding websites

1. <http://www.projectreporter.nih.gov/reporter.cfm> {a site from which to search for currently funded NIH grants}
2. <http://www.nsf.gov/awardsearch/> {NSF awards data base}

Scientific document search engines

1. <http://www.ncbi.nlm.nih.gov/pubmed/> {for searching scientific journal citations "PubMed/Medline"}
2. <http://toxnet.nlm.nih.gov/> {the National Library of Medicine's Toxline database of toxic chemicals}

Scientific reagent and instrumentation companies:

1. <http://www.bdbiosciences.com/reagents/#research> {a supplier of monoclonal antibodies to human, mouse antigens and a flow cytometry company}

Other Links:

1. Immunoglobulin Isotype Website
 - a. http://www.whfreeman.com/catalog/static/whf/kuby/con_index.htm?99anm
2. Complement system review website
 - a. <http://www.complement-genetics.uni-mainz.de/>
3. The SCID Network
 - a. <http://www.scid.net/>
4. Online Mendelian Inheritance in Man
 - a. <http://www.ncbi.nlm.nih.gov/omim>
5. Mouse Genome Informatics (MGI)
 - a. <http://www.informatics.jax.org/>
6. Roche's HIV Page- Animated viral "lifecycle", HIV drug targets, and mechanisms of action
 - a. <http://www.roche-hiv.com/portal/Roche-HIV/hivlifecycle>
7. The history of xenotransplantation
 - a. <http://www.ncbi.nlm.nih.gov/pubmed/15693840>
8. Human Genome Project Information- Gene Therapy
 - a. http://www.ornl.gov/sci/techresources/Human_Genome/medicine/genetherapy.shtml
9. Robert C. Gallo's book, "Virus Hunting: AIDS, Cancer, And the Human Retrovirus : a Story of Scientific Discovery"
 - a. http://www.amazon.com/Virus-Hunting-Retrovirus-Scientific-Discovery/dp/0465098150/sr=1-1/qid=1163709796/ref=sr_1_1/002-7940394-5952052?ie=UTF8&s=books
10. Animated review of PCR
 - a. <http://library.thinkquest.org/24355/data/details/media/polymeraseanim.html>
11. Great book about cancer by Robert Weinberg "One Renegade Cell"
 - a. http://books.google.com/books?id=r-PsCQRE7wMC&dq=one+cell+weinberg&printsec=frontcover&source=bn&hl=en&ei=m28GTMfqlcP38Abf2t3nCw&sa=X&oi=book_result&ct=result&resnum=4&ved=0CCAQ6AEwAw#v=onepage&q&f=false
12. Video showing how Herceptin targets HER2 overexpressing breast cancer
 - a. <http://www.youtube.com/watch?v=48VSU4AZ-L0&NR=1>
13. Flash Animation- DNA Microarray Methodology
 - a. <http://www.bio.davidson.edu/Courses/genomics/chip/chip.html>
14. Transplantation links:
 - a. Whole body transplantation
 1. <http://www.nytimes.com/1998/05/05/science/essay-from-science-fiction-to-science-the-whole-body-transplant.html?sec=health>
 - b. Robert Olen Butler's book "Severance"
 - i. <http://www.amazon.com/Severance-Stories-Robert-Olen-Butler/dp/0811856143>
 - c. The brain that wouldn't die
 - i. <http://www.youtube.com/watch?v=z8zYQ2QgNwY>
 - d. animation of transplant surgical procedure to attach hand (a "composite tissue")
 - i. <http://www.youtube.com/watch?v=pUdfi5MALwg>
15. Mouse genetics; concepts and applications (access to the whole book)
 - a. <http://www.informatics.jax.org/silver/>
16. Check out these great animations!
 - a. Mechanisms of RNAi
 - i. <http://www.nature.com/focus/rnai/animations/animation/animation.htm>
 - b. XVIVO/Harvard's award-winning animation, "The Inner Life of a Cell"
 - i. <http://www.xvivo.net/the-inner-life-of-the-cell/>

- c. how an AIDS vaccine might work
 - i. <http://www.xvivo.net/how-an-aids-vaccine-might-work/>
- d. cell rolling and phagocytosis and T cell killing
 - i. <http://www.xvivo.net/healing-visualization-return-to-wholeness/>
- 17. Georges Kohler's Nobel Prize speech for his work on monoclonal antibodies and hybridoma technology
 - a. http://nobelprize.org/nobel_prizes/medicine/laureates/1984/kohler-lecture.html
- 18. Albert F. Blakeslee taught the first American university class in genetics in Storrs in 1908.
 - a. <http://oasis.lib.harvard.edu/oasis/deliver/~far00002>
 - b. <http://advance.uconn.edu/2000/000612/000612hs.htm>
- 19. Nobel lecture on histocompatibility by George Snell
 - a. http://nobelprize.org/nobel_prizes/medicine/laureates/1980/snell-lecture.pdf
 - b. Snell biography http://nobelprize.org/nobel_prizes/medicine/laureates/1980/snell.html
 - c. Craig Venter speaking about the first synthetic cell and its implications for vaccine research
 - i. http://www.youtube.com/watch?v=Ce8ZVyUqY-l&feature=player_embedded#at=61
 - ii. <http://www.jcvi.org/cms/research/projects/first-self-replicating-synthetic-bacterial-cell/overview/>