The last exam will cover new material from pdf Chapter 11 on Cancer, pdf Chapter 12 on Biotechnology and Ch4 Beyond Mendel (75%). The exam will also have review material from other units (25%). The exam will be worth 75 points max. You can write notes on both sides of a 3x5 card and use it on the exam. The exam will be held on Thursday, Dec 13th, starting at regular class time, 3:30 pm. You have until 5:30 to finish the exam. If you need more time, we can walk over to ZH-127.

Chapter 11 – Gene Regulation and Cancer

* What is cancer?
	+ Cancer includes a variety of diseases
		1. normal gene regulation fails
		2. cells escape control of the cell cycle
		3. mitosis becomes uncontrolled
		4. mutations accumulate in somatic cells
* Are all tumors cancerous? - No
	+ Benign tumor
		1. cells that escape control of the cell cycle
		2. cells are in one place – forming a mass
		3. usually less deadly
	+ Cancer (metastatic tumor)
		1. cells that escape control of the cell cycle
		2. cells that have or will move from the place of origin
		3. can metastasize – move to a new location in the body
		4. harmful to health and can be deadly
* Viruses can cause cancer
	+ Examples – human papilloma virus, viruses in chickens
	+ Viruses that cause cancer can become permanent residents in host cells by inserting their nucleic acid into the DNA of host chromosomes (provirus)
	+ Viruses cause cancer by inserting an oncogene into the host cell DNA
* What is the normal function of a proto oncogene?
	+ Causes cell division to happen – the ‘gas’ petal of cell division, but at the speed limit
* Oncogene is a cell division gene that has been mutated and causes the cell cycle to become uncontrolled
	+ A virus can infect a cell with an oncogene
* What is the normal function of a **Tumor-suppressor** gene?
	+ Genes whose products **inhibit cell** division
	+ These genes are called **tumor-suppressor genes** because the proteins they encode normally help prevent uncontrolled cell growth
	+ They normally put the brakes on cell
	+ If mutated, the cell cycle gets out of control
* Progression of cancer
	+ A malignant tumor develops as mutations accumulate
	+ convert proto-oncogenes to oncogenes and
	+ knock out tumor-suppressor genes.
* Cancer Risk and Prevention
	+ Cancer is the second leading cause of death (after heart disease) in most industrialized countries
	+ Up to 15% of cases have a heritable component
	+ Which risk factor is associated with cancer of the colon and rectum?
		- High fat diet
	+ Cancer and tobacco
		- The “smoking gun” was found in 1996, when researchers added one component of tobacco smoke, called BPDE, to human lung cells growing in the lab.
		- The researchers showed that BPDE binds to a gene within these cells called *p53*.
		- That gene codes for a protein that helps suppress the formation of tumors.

Chapter 12 Biotechnology

* People have been selecting organisms for desired characteristics for all of recorded history
* Date palms had the first active breeding programs.
* What is biotechnology?
	+ the manipulation of organisms to make useful products
	+ What is CRISPR- CAS9? Re-listen to the Radiolab called ‘Antibodies’, embedded in ppt
	+ Cas9 is like a guided missile, with an ­ **RNA** molecule as the guidance system.
* CRISPR can ‘knock out’ a gene. What does that mean and how does CRISPR do that?
	+ *When a gene is ‘knocked out’ that means it is mutated, so it will no longer express the protein it codes for. CRISPR can make cuts in a coding gene that introduce mutations that disrupt the genetic code. The gene then makes a non-functional version of the polypeptide.*
	+ Where was CRISPR CAS9 discovered?
		- It is a bacterial immune system used to fight viruses
	+ What has CRISPR – CAS9 been used to modify.
		- It can modify the DNA of living (somatic cells)
		- It can be used to modify embryos
		- It seems to work on any cell with DNA… possibilities are endless
	+ Has CRISPR been used to make a permanent change in an embryo? Yes
	+ Have those embryos been allowed to develop in to human babies?
		- Yes, as of Nov 2018, a Chinese scientist claims to have used in vitro fertilization to implant embryos modified by CRISPR. The researcher inactivated a gene associated with HIV transmission in the embryos. Those embryos were implanted into the egg donor (mother) using in vitro fertilization methods, and were allowed to grow into twin baby girls.
	+ Is what the Chinese scientist did legal? The scientist blatantly violated Chinese regulations that govern in vitro fertilization guidelines.
* What is genetic engineering?
* Why did scientists create GloFish?
	+ Glow fish have been modified through reproductive cloning. A gene that encodes a protein that fluoresces called (Green Florescent protein, obtained from jelly fish is used to indicate the expression of other genes of scientific interested.
	+ The GFP protein is a reporter gene.
* Cats with GFP reporter genes were engineered as part of a feline immunodeficiency model (feline aids…).
* Review PPT on Recombinant DNA Techniques
* What is gene cloning
* What are restriction enzymes (see ppt)?
* What is Humulin?
	+ Humulin is human insulin produced by genetically modified bacteria
	+ First human medicine made using recombinant DNA technology (1978)
* AquaAdvantage Salmon – What is it and where can you eat it?
* Review Human Gene Therapy
* Read pages 225 through 228 on ‘DNA Profiling’ and ‘Forensic Science,’ then answer the questions below.
* What are the steps of DNA profiling?
1. *DNA is sampled from a crime scene, suspect or victim*
2. *Certain regions of DNA are copied many times, so they will be visible when combined with a fluorescent dye.*
3. *Fragments of DNA are compared to identify individuals – DNA fingerprint…*
* DNA Profiling uses three important techniques. What are they? Describe each step in one or two sentences.
1. *polymerase chain reaction (PCR) - DNA polymerase is used to make copies of certain parts of the DNA. Many copies of DNA are needed, so that we can see the DNA when dyes that fluoresce are added to it.*
2. *short tandem repeat analysis (STR) – The DNA of most humans is 99.9% identical. How do we find the places that make individuals unique? There are super variable regions of DNA that do not code for genes or make proteins. These regions called STRs can act as a DNA fingerprint. Every person has a unique profile and there is less than a 1 in a billion chance that two unrelated people will be exactly identical. These regions are short and repeat variable numbers of times. Why are these repeats so variable among individuals? Because DNA polymerase is not the best counter in the world…*
3. *gel electrophoresis – This is how we can look at the DNA that has been amplified with DNA polymerase during PCR. DNA is mixed with a molecule that will make it fluoresce under an ultraviolet light. The gel then separates the DNA fragments based on size. Shorter fragments move through the gel faster than longer pieces of DNA. The lengths of the STR molecules are used to determine the identity of an individual.*
* How genetically similar are most humans to each other? What is the CODIS?
	+ *Most humans are 99.9 percent identical. The Combined DNA Index System (CODIS) is a database of STR regions that is used to compare the remaining 0.1% of the human genome that is variable.*
* Who is Earl Washington?
	+ *Earl Washington is a man who spent 20 years in prison for a murder he did not commit. STR analysis was used to show that his DNA did not match the DNA found at the scene of the crime. STR evidence was also used to match the crime scene DNA to a different person.*
* As of 2017, the ‘Innocence Project’ has exonerated how many people?
	+ *At least 350 people*
* Read pages 229 to 232 on Bioinformatics.
* What is genomics?
	+ *The study of the complete set of genes and nucleotides in an organism. The first organism to be completely sequenced was Haemophilus influenzae, a bacterium that can cause pneumonia in humans.*
	+ *Yeast, Saccharomyces cerevisiae, was the first eukaryote to have its full sequence determined*
	+ *Roundworm, Caenorhabditis elegans, was the first multi-cellular organism*
	+ *Humans - the first human genome took 13 years and cost $100 million, an individual's genome can be sequenced in a matter of hours for less than $1,000.* [*Netfix just paid $100 million*](https://www.recode.net/2018/12/4/18126596/friends-netflix-warnermedia-att-hulu-apple-deal) *for the rights to the TV show ‘Friends’ for 1 year…*
* Figure 12.20 compares whole genomes of organisms. Which organisms have approximately the same number of coding genes as humans?
	+ *Roundworm/nematode, Caenorhabditis elegans; duck-billed platypus, Ornithorhynchus anatinus; Giant Panda, Ailuropoda melanoleuca; lab rat, Rattus norvegicus; wallaby, Macropus eugenii; chimpanzee, Pan troglodytes*
* What time period did Neanderthals live in Europe and Asia?
	+ *300,000 to 30,000 years ago*
* When did modern humans move from Africa to Europe and Asia?
	+ *Approximately 50,000 years ago.*
* When did Neanderthals disappear from the fossil record in Europe and Asia?
	+ *30,000 years ago*
* What explains the disappearance of Neanderthals from Europe and Asia?
	+ *DNA evidence suggests that starting as far back as 70,000 years ago modern human ancestors acquired genes from Neanderthals by interbreeding with them in Europe and Asia. It is likely that the ancestors of modern humans out-competed Neanderthals and displaced them*
* Ethics – Can an insurance company require you to disclose a genetic test to them?
	+ Genetic Information Nondiscrimination Act of 2008 [(GINA).](http://www.ginahelp.org/GINAhelp.pdf)
	+ Title I of the act prohibits insurance companies from requesting or requiring genetic information during an application for health insurance.
	+ Title II provides similar protections in employment.

Chapter 4 cont. Beyond Mendel

* What does expression mean?
	+ DNA to RNA to protein...
	+ to understand dominance molecular genetics and expression are important...
	+ Levels of expression – Phenotype can be considered at multiple levels. Cystic fibrosis has a cell phenotype (types of transmembrane proteins) and a whole organism phenotype (disease or no disease).
* Additional Factors at a Single Locus Can Affect the Results of Genetic Crosses
1. Types of Dominance (continued) - How the phenotype of the heterozygote relates to the phenotype of the two homozygotes...
	* + - If the heterozygote **phenotype** is the same as one of the homozygotes
				* complete
			- If the heterozygote phenotype is **intermediate** **between** the homozygotes
				* incomplete
			- If the heterozygote is has both phenotypes **fully expressed**
				* Codominant
2. Penetrance - the percentage of individuals having a particular genotype that express the expected phenotype
3. Lethality – mice that do not develop…
* Multiple alleles – every organism can only have two forms of a gene, but a population of organisms has many alleles that control a trait.
	+ Example
		- ABO blood type, three phenotypes, three alleles, and six genotypes
		- Cystic Fibrosis – more than more than 850 mutant (non-functional) alleles have been reported, most people have the same, functional, ‘wildtype’ allele.
	+ Compound Heterozygosity
		- The disease cystic fibrosis (CF) is considered a ‘recessive disease’, because you need at least one functional transmembrane CR protein to have normal lung function. However, this disease does not follow classic concepts of dominance. A heterozygote without disease can have one normal CF allele and one nonfunctional CF allele. A heterozygote can also have two non-functional CF proteins and have the disease. In cystic fibrosis the heterozygote can have CF or be normal. **Cystic fibrosis is said to have compound heterozygosity**.
* Gene Interaction Takes Place When Genes At Multiple Loci Determine a Single Phenotype
	+ Epistasis: one gene masks the effect of another gene. Example Labrador retriever coat color
	+ Two genes control one trait – example bell pepper color
* Ch1. Intro to genetics
	+ Evolution –
		- Is change through time
		- Genetic variation is a fundamental component of evolution, otherwise there would be no differences for natural selection to chose among…
		- Natural Selection depends on the environment – go over the Hopi example. Selection favors albinos in the Hopi culture because albinos are revered. Albinos have greater incidence of skin cancer. These observations are consistent with a high rate of albinism in Hopi relative to cultures that do not regard albinism favorably…
		- Is natural selection the only way that evolution can happen?
			* No, example - artificial selection…
	+ Intro to Genetics
		- What is a genome – all of the molecules of heredity - the genome is made of nucleic acids, DNA and RNA.
		- People have been manipulating organisms genetically for 1000s of years
		- Genetic engineering of insulin
		- Zebrafish gene and human melanin – fish used to understand human skin color variation
			* Many characters are controlled by multiple genes
			* Hair and skin color are controlled by more than one gene…
		- What is cell theory?
			* according to this theory, all life is composed of cells, cells arise only from preexisting cells, and the cell is the fundamental unit of structure and function in living organisms
* pdf Ch - Chemistry and Biology Intro
	+ Basic Chemistry
		- Atom, element, proton, neutron, electron, ion, molecule, types of bonds…
	+ Water, polarity and hydrogen bonding
		- Water is special…
		- polar molecule - uneven distribution of charge
		- Hydrogen bonding review
		- Oxygen is electro-negative and keeps the electrons for itself
		- Acid/base is not covered…
	+ Molecules of Life
		- Polymers are made of monomer
		- Four types of macromolecules important to life
		- The molecule of heredity are nucleic acids - polymer composed of nucleotides
		- DNA is a double helix
		- How do DNA and RNA differ?
		- DNA is found in chromosomes…
* Ch2. Cycle, Mitosis, Meiosis
	+ What are the major phases of the cell cycle? - Interphase and M-phase (Mitosis/Meiosis)
	+ When does DNA replicate? S-phase of Interphase
	+ What are homologous chromosomes?
		- They are chromosomes that have version of the same genes.
	+ What are sister chromatids?
		- They are exact copies of a chromosome that exist after DNA replication, but before mitosis/meiosis II
	+ Mitosis – What major events happen at each stage?
		- Prophase – chromatin condenses into visible structures
		- Metaphase – chromosomes are lined up at the metaphase plate
		- Anaphase – sister chromatids separate
		- Telophase – chromosome migration is completed and nuclear envelope reforms
	+ Mitosis and Meiosis –
		- During anaphase of mitosis sister chromatids separate
		- During anaphase1 of meiosis homologous chromosomes separate
		- During anaphase 2 of meiosis sister chromatids separate
	+ What is the point of meiosis?
		- To generate haploid cells that that can combine during sexual reproduction (fertilization)
	+ What does fertilization do to in terms of the number of chromosomes in a cell?
		- Restores the diploid number
	+ Why is sex important? – Sex creates variation
	+ What produces variation?
		- Crossing over (recombination)
		- independent assortment of homologous chromosomes during meiosis
		- sexual reproduction - combining two different genomes creates variation
* Ch3. Mendelian Inheritance
	+ Heredity - transmission of traits from one generation to the next.
	+ Genetics - scientific study of heredity
	1. Monohybrid cross –
		+ What are the steps in a Monohybrid Cross
		+ Cross between two individuals that differ in a single characteristic
	2. **Principle of segregation (Mendel’s** first law) - Principle of heredity discovered by Mendel that states that each diploid individual possesses two alleles at a locus and that these two alleles separate when gametes are formed, one allele going into each gamete.
	3. **Independent assortment** – two genes on different chromosomes will assort into gametes independently of each other.
	4. **Concept of dominance -** Principle of heredity discovered by Mendel stating that when two different alleles are present in a genotype, only one allele may be expressed in the phenotype. The dominant allele is the allele that is expressed, and the recessive allele is the allele that is not expressed."
	5. Punnett squares – know how to do them - a way to organize the genotypes and phenotypes of offspring produced in a genetic cross.
	6. What does pure breeding mean?
		+ Homozygote, (HH or hh)

Ch. 4 Beyond Mendelian Inheritance

* 1. Introduction – Cuenot’s Example
		+ Work the ratio and show that lethality changes ratios
		+ Beyond Mendel – refers to reasons why crosses deviate from Mendel’s expected ratios.
	2. Sex Determination
		+ Review – why is sex important. It is the basis for genetic variation for evolution to act upon…
		+ How is sex determined in humans?
		+ What is the difference between an autosome and a sex chromosome?
		+ How many do humans have? 22 sets of autosomes, one set of sex chromosomes.
	3. Sex linked Genes – What are they
		+ Most sex-linked genes are on the X-chromosome.
		+ Why is that? Because the Y-chromosome only has 200 genes on it. Most have been lost…
		+ Are x and y chromosomes homologous?
			1. No, because they don’t code for the same genes.
			2. They have pseudo-autosomal regions that can cross over during meiosis
	4. X-linked traits
		+ Problems solving with x-linked
		+ Fly eyes, hemophilia, color-blindness
		+ Why are flies a good genetic model?
		+ Make sure you can do the problem on **page 83** in your book about color blindness.
		+ X-linked pedigree – hemophilia example –
			1. Expression skips generations
			2. Female carriers
			3. Males sons of female carriers with the disease
	5. Y-linked
		+ SRY – what does it do?
		+ What chromosome is it on?
		+ DNA from Y-chromosome can be used to understand paternity
	6. Types of Dominance –
		+ Complete – one allele masks the other
		+ Incomplete – blending, the heterozygote is intermediate between homozygotes –
			1. Example – red, pink, white flowers
		+ Codominance – both alleles are expressed fully.
			1. Example – MN-red blood cell antigens.
	7. Dosage compensation –
		+ One chromosome is inactivated early in development so the products of genes encoded on the x – chromosome are the same in males and females.
		+ Example – female cat with tortoise-shell coat
	8. Lethal Alleles
		+ One of the genotypes does not make it to development, so the genotype/phenotype ratios are obscured.
		+ Example Cuenot’s Mice –
		+ **The pure-breeding homozygous dominant (YY) mice die, so the ratios are 2:1 (2/3 yellow - Yy to 1/3 gray - yy)**
	9. Penetrance – Extra credit question
		+ Polydactyly (an extra digit) is caused by a dominant allele. The wild-type alleles produce five digits per limb. However, people who have the polydactyly allele sometimes do not have more than 5 digits per limb.
		+ This is called incomplete penetrance.
	+ Penetrance describes the degree to which the allele produces the expected phenotype. 38 out of 42 people who have the allele have an extra digit. (=90% penetrance)
* Scientific method –
	+ What are the steps? Observe, question, hypothesis with expectations, test, do results support hypothesis?
	+ Hypothesis is a possible explanation for an observation or question…
	+ Theory – A well-tested and universally accepted explanation for an observation or question.
* Ch.10 DNA to RNA to Proteins
	1. DNA basics
		+ **DNA is the molecule of heredity, not protein (see Hershey-Chase Experiment)**
		+ Nucleic acids are either DNA or RNA
		+ What are nucleic acids (polynucleotides) made of? Nucleotides
		+ Components of a nucleotide - phosphate, sugar, base
		+ Bases give the nucleotide its identity as – A, T, C, G
		+ What are the differences between DNA and RNA?
		+ What kind of bond holds nucleotides together? Covalent
		+ What kind of bond holds the base pairs of strands together? Hydrogen
		+ Complementary base pairing rules – A to T, C to G
		+ What did Watson, Crick and Franklin figure out about DNA?
			1. a helix (spiral)
			2. with a uniform diameter
			3. made up of two polynucleotide strands.
			4. They used the X-ray image of DNA produced by Rosalind Franklin.
	2. DNA Replication
		+ Produces a new double helix that has one old strand and one new strand
		+ What enzyme copies DNA? DNA polymerase
		+ What part of the cell cycle does DNA replication happen in? s-phase of interphase
		+ Where in the cell does DNA replication happen? nucleus
	3. Relationship between genes, alleles, genotype and phenotype
		+ Central Dogma of Molecular Biology - DNA dictates the production of a protein
		+ Genetic Code – converts the language of nucleic acids (DNA/RNA) into polypeptides (then protein).
		+ A polypeptide is a chain of amino acids
		+ Three nucleotides code for a single amino acid (codon)
		+ Example - An RNA molecule contains the nucleotide sequence CCAUUUACG.
	4. DNA to RNA (transcription)
		+ If eukaryotic, transcription happens in the nucleus
		+ During elongation the enzyme RNA polymerase adds nucleotides to the growing RNA strand
		+ Exons are the regions that then get translated into polypeptides
		+ mRNA is the sequence of nucleotides that gets translated into a polypeptide
	5. mRNA to polypeptide (translation)
		+ mRNA leaves the nucleus and goes into the cytoplasm to be translated into a polypeptide with the help of a ribosome.
		+ The players (all nucleic mostly nucleic acids-
			1. mRNA – has the code for the polypeptide that it got from DNA (transcription).
			2. transfer RNA (t-RNA) – a shuttle that brings amino acids to the growing polypeptide chain – a nucleic acid that has an amino acid bonded to it. Has two important parts, the amino acid binding region and the anticodon that is complementary to the mRNA codon.
			3. ribosomes – cellular machine made out of RNA that translates the genetic code of RNA to amino acids
				1. complex RNA machine that translates mRNA to a polypeptide by adding amino acids in a particular sequence.
				2. Small subunit bind the mRNA molecule
				3. Large subunit accepts transfer RNAs in the order dictated by the mRNA sequence following the genetic code.
	6. Why and how were researchers able to make glow in the dark pigs?
		+ See pgs 179-180
	7. Mutations – Any change in the nucleotide sequence of a cell’s
		+ Mutations can involve large regions of a chromosome or just a single nucleotide pair, as in sickle-cell disease.
		+ When do mutations happen?
			1. During DNA replication or recombination
		+ Mutagens – chemicals or radiation that cause the rate of nucleotide changes to increase.
		+ Carcinogen – Mutagen that causes cancer rates to increase
		+ Mutations and variation – allelic variation
	8. Viruses
		+ is an infectious particle consisting of little more than “genes in a box”:
		+ protein coat, nucleic acid as molecule of heredity, sometimes a membrane envelope
		+ Are viruses alive?
			1. No
			2. A virus cannot reproduce on its own, and thus it can multiply only by infecting a living cell and directing the cell’s molecular machinery to make more viruses.
			3. Prophage - viral DNA is inserted into the chromosome of a bacterium. Once there, the phage DNA is referred to as a **[prophage](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml%22%20%5Cl%20%22P7000496869000000000000000007860%22%20%5Ct%20%22_blank)**.
				1. Diseases caused by prophage toxins – Diptheria/Botulism
			4. Plant viruses – cause disease in crop plants
				1. Tobacco mosaic virus – structure was determined by R. Franklin using x-ray crystallography.
				2. Most are RNA viruses
				3. No ‘cure’ prevent infection/cross contamination
				4. Engineer disease resistant plants.
			5. Animal Viruses –
				1. Key points – The amount of damage a virus causes the body depends on two factors

how quickly the immune system responds to fight the infection - vaccinations prime the immune system so your body can respond to infection quickly

on the ability of the infected tissue to repair itself. – tissues have variable ability to regenerate, example skins cells vs. nerve cells.

* + - * 1. the immune system of your body fights viruses. There are no antibiotic equivalents for ‘killing’ viruses
			1. HIV/Aids –
				1. HIV is a retrovirus
				2. Has an enzyme called reverse transcriptase that makes a DNA copy of the virus RNA.
				3. Breaks the DNA to RNA rule….
				4. Provirus – Viral DNA is inserted into eukaryotic host chromosome
				5. AZT is similar to the nucleic acid thymine, so it messes up replication.
				6. Is there a cure for AIDs?
			2. What is a prion?
				1. A protein that causes other proteins to become non-functional.
				2. What does transmissible mean?
				3. Is variant creutzfeldt-jakob (human mad cow) disease and emerging disease? - No
		- Flu virus – Deadliest virus
		- the pandemic of 1918–1919 killed 40 million people worldwide in 18 months
		- two times the number than died in WW1
		- H1N1 strain of 2009 killed about 20,000 people,
		- Considered at the population level, does the flu virus reduce death and hospitalization among the elderly in the winter flu season?
			1. yes
* Ch. 11 Gene Regulation
	1. Introduction
		+ Gene regulation - mechanisms that turn on certain genes while other genes remain turned off.
			1. Allows for cells to become specialized
			2. Gene expression – overall process where genetic information flows from DNA to RNA to proteins
			3. Review figure. 11.1
	2. Gene Regulation in Bacteria – Review the *lac* operon – we covered this thoroughly in class, so make sure you review it.
	3. Gene Regulation in Eukaryotes –
		+ What is a Eukaryote? –
		+ Usually multicellular organism that has cells membrane bound organelles and DNA within a nucleus
		+ Your book uses a ‘pipeline’ analogy - 11.3 The gene expression “pipeline” in a eukaryotic cell.
			1. What do the valves in the pipeline represent
			2. What is the most important type of regulation in Eukaryotes
				1. Transcription
	4. Cloning Plants and Animals
		+ Key Point - One of the most important take-home lessons from this chapter is that all body cells contain a complete complement of genes, even if they are not expressing all of them
		+ **Cloning** is the process of producing genetically identical individuals of an organism either naturally or artificially.
		+ In nature, many organisms produce **clones** through asexual reproduction.
		+ Regeneration - the regrowth of lost body parts. When a salamander loses a tail, for example, certain cells in the tail stump **reverse their differentiated** state, divide, and then differentiate again to give rise to a new tail
		+ Reproductive cloning in mammals–
			1. **nuclear transplantation** – diploid nucleus from a somatic cell is put into an egg cell. Then after some 100’s of cell divisions the cloned organism is implanted into a surrogate uterus
			2. Practical application – conservation, cloning extinct mammals, production of important materials.
				1. Spider silk in goats milk
				2. pig clones that lack a gene for a protein that can cause immune system rejection in humans.
			3. Could Jurassic park happen? … maybe
			4. Cloned animals might age more quickly… telomers affected during cloning
			5. Have nuclear transplants been done in humans?
				1. Yes, May 2013, the Oregon group reported the successful derivation of human embryonic stem cell lines derived through somatic cell nuclear transplant (SCNT).
				2. Chung, Y. G., Eum, J. H., Lee, J. E., Shim, S. H., Sepilian, V., Hong, S. W., ... & Dittman, R. E. (2014). Human somatic cell nuclear transfer using adult cells. Cell stem cell, 14(6), 777-780.
			6. Have embryos from nuclear transplants been placed in a human surrogate mother?
				1. Although the scientific methods are highly developed, laws prevent reproductive cloning in humans in all countries.
				2. In 2015 it was reported that about 70 countries had banned human cloning
			7. First primate reproductive clones - Song, H., & Ming, G. L. (2018). Breaking the final barrier in reproductive animal cloning: macaque monkeys cloned. National Science Review, 5(3), 301-303.
		+ Therapeutic cloning **-** The purpose of this procedure is not to produce a living organism but rather to produce embryonic stem cells (ESC).
			1. ESC - removing cells from an early embryo and growing them in laboratory culture.
				1. Differentiation of embryonic stem cells through gene expression
			2. Umbilical cord cells - a treatment for leukemia
			3. Adult stem cells – example bone marrow … not as universal as embryonic stem cells
	5. Ch11. - Cancer and Gene Regulation – see first section of this review

Biology and Society Topics Summary

The summary below is mostly for your own reference. It would be a good idea to make sure you understand CRISPR.

Devils – process of science

* People have many ways to understand the world around them…
* For Cristo Baars – Art & Photography of animals
* Through is photographs of Tasmanian devils he began the process that allowed scientists to figure out that the devils have a transmissible cancer…
* <http://www.radiolab.org/story/91714-devil-tumors/> The Devil story starts ~ 5 min into the program (15 min long)

Radio isotopes – How old are cells?

* <https://www.wnycstudios.org/story/carbon/>

Flu Virus pg. 171 (pdf)

* deadliest in the world
* H1N1 strain became first global pandemic of this millennium in 2009.

Glow in the Animals – why?

* The pigs are genetically modified. They have a jellyfish gene that produces a protein that fluoresces green, green fluorescent protein (GFP), pg. 178.
* GloFish – First GM Pet - http://edition.cnn.com/2003/US/11/21/offbeat.glofish.reut/
* Cats with GFP - <https://blogs.scientificamerican.com/observations/jellyfish-genes-make-glow-in-the-dark-cats/>

Prion Disease

* Creutzfeldt-Jakob and bovine spongiform encephalopathy
* https://www.bbc.com/news/uk-scotland-north-east-orkney-shetland-45901043

Infective Heredity –

* Horizontal gene transfer - virus and mammal evolution
* Radiolab adapted from a book called ‘Tangled Tree’ by David Quammen
* https://www.iheart.com/podcast/radiolab-18894587/episode/infective-heredity-29876065/

Reproductive Cloning –

Spider silk in goat milk

* https://www.nsf.gov/news/special\_reports/science\_nation/spidersilk.jsp

AquaAdvantage Salmon –

<https://www.scientificamerican.com/article/first-genetically-engineered-salmon-sold-in-canada/>

GM Atlantic Salmon

growth-hormone gene from Chinook salmon (Oncorhynchus tshawytscha),

genetic regulatory elements from a third species, the ocean pout (Zoarces americanus)

enable the salmon to produce a continuous low level of growth hormone.

CRISPR –

in vivo gene editor, was just used to modify genes related to HIV infection in human embryos, and the embryos were allowed to develop into children.

* Antibodies part1 – CRISPR-Cas9 - <https://www.wnycstudios.org/shows/radiolab/podcasts>
* CRISPR update - <http://www.frontlinegenomics.com/rich-media/10236/listen-crispr-update-radiolab/>
* CRISPR – Human Gene Editing - IFF - <https://www.npr.org/sections/health-shots/2018/11/26/670752865/chinese-scientist-says-hes-first-to-genetically-edit-babies>

Biotechnology & Responsibility

* Science Fiction Meets Science - <https://news.nationalgeographic.com/news/2010/10/1001027-rabies-influenza-zombie-virus-science/>