ISE 870 – TEACHING COLLEGE SCIENCE
Spring 2018

Instructor: **Dr. Joyce Parker**
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Office Hours by Appointment

General Course Goal

To introduce participants to the theory and practice of student-centered college teaching. Students will be able to use an understanding of how people learn, the basics of curriculum design, and a range of teaching and assessment strategies and instructional technology to plan for, teach, and analyze effective science teaching. In addition, students will discuss the roles and responsibilities of teaching within the university setting.

Tentative Schedule and Session Objectives – Revised January 27, 2018

Note: bullets are objectives for each day

Date	Topic	Homework due
Jan 8	**Introduction: Student-centered teaching and backward design** • clarify objectives and expectations of course • identify the range of syllabus components and the role of each In class reading – Code of Teaching Responsibility	Bring sample syllabus
Jan 15	**No class – Martin Luther King Holiday**	
Jan 22	**How people learn and implications for teaching** • explain how people learn – what goes on in the mind of a learner	Read • Rutherford & Alhgren – Chpt 13 • Bodner • Complex Cognition – chpt3 • Redish Sec 2 – 4 • Kahneman

Jan 29	**Objectives and assessment in backward design** • analyze and write course objectives and associated assessment and big ideas that combine content and scientific practices and take into account discipline, departmental, university, and national standards In class reading – Bloom	Read: • Wiggins & McTighe • Angelo & Cross
Feb 5	• analyze and write course and content objectives and associated assessment In-class reading: Woodin *et al.;* Brownell *et al.;* ACS Program Recommendations; A Framework for K12 Science Education Teaching strategies • plan for effective information presentation	Write sample obj & assessment Read: • Bransford et al.
Feb 12	**Mini-lecture I – presenting information** • plan, deliver, and analyze lectures Useful reference – NRC Science Teaching Reconsidered	Mini-lecture Lesson plan
Feb 19	**Textbooks & helping students read** • evaluate a textbook from multiple perspectives • design activities that support use of reading material in flipped classrooms In-class readings: Helping College Students Read Class structures • develop class structures that support student learning	bring textbook & completed evaluation, Read: • Eddy et al.
Feb 26	**Student-centered teaching and active learning** (PBL, case studies, clickers, *etc*.) • observe and analyze active learning situations and materials	Report on classroom observations Bring sample of an in-class activity Read: • Gijbels et al. • Linton et al.
Mar 5	**Spring Break**	
Mar 12	**Labs – Science-specific group work** • identify multiple purposes of lab and demos • develop laboratory materials for investigations **Teaching Philosophies** In class – Montell; Types of Laboratory & Inquiry Experiences	Read: • Herman
Mar 19	**Science-specific teaching strategies and instructional technology** **Guest Speaker – Dr. Stephen Thomas** • observe and analyze active learning situations involving instructional technology In class – Types of Labs, NSES Inquiry	Read: • USDeptofEd – Means et al.

Mar 26	**Group work in large classes** **Guest Speaker – Dr. Andrea Bierma** • articulate principles for designing and managing group work **3 purposes of assessment** • analyze student work for the purpose of giving feedback to students • use assessment data to modify instruction • write a rubric for grading an open-ended assignment	Read: • Johnson et al. • Beichner et al. • Smith and Tanner • Smith et al. • Kracjik & McNeill
Apr 2	**MOOCs, Hybrid and online courses** **Guest Speaker – Dr. Stephen Thomas** • Analyze the pros and cons of MOOCs, hybrid, and online classes	Read: • NY Times article on MOOCs • AFT on MOOCs • Griffiths et al.
Apr 9	**Mini-lecture II – active learning** • plan, deliver, and analyze active learning tasks	Mini-lecture Lesson plan
Apr 16	**Multiple responsibilities of university instructors and students** • guest speaker, MSU Ombudsman Equity issues • develop solutions to scenarios involving equity issues	
Apr 23	**Presentations** • develop and implement instructional materials based on sound educational principles	Presentations Written projects due May 4
May 3 Thurs	**Presentations 12:45pm - 2:45pm** • develop and implement instructional materials based on sound educational principles	Presentations Portfolios due May 4

Readings

Readings listed below without urls are available on the D2L course site.

For observing interactive classrooms

Wieman & Gilbert. (2014). The Teaching Practices Inventory: A New Tool for Characterizing College and University Teaching in Mathematics and Science. CBE—Life Sciences Education Vol. 13, 552–569, Fall.

Sawada, Piburn, Judson, Turley, et al. (2002) Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol. School Science and Mathematics Oct, 102, 6, 245.

Jan 8

Code of Teaching Responsibility from MSU Faculty Handbook.

Jan 22

Rutherford & Ahlgren (1990) Science for All Americans. Chpt. 13 Effective Learning & Teaching. Washington: Oxford Press. http://www.project2061.org/tools/sfaaol/Chap13.htm

Bodner (1986) *Constructivism: A Theory of Knowledge,* J. Chem. Ed 63. pp. 873-878.

Sterberg & Ben-Zeev (2001) *Complex Cognition: The psychology of Human Thought.* New York: Oxford Press. Pp. 31–57.

Redish (2003) *A Theoretical Framework for Physics Education Research: Modeling Student Thinking.* The Proceedings of the Enrico Fermi Summer School in Physics, Course CLVI (Italian Physical Society, 2004). Concentrate on sections 2–4.

Kahneman (2011) *Thinking Fast and Slow.* New York, NY: Farrar, Straus and Giroux.

Jan 29

Wiggins & McTighe (1998) *Understanding by Design.* Alexandria, VA: Assoc. for Supervision & Curric. Dev. pp. 9–13, 18.

Angelo & Cross (1993) Classroom Assessment Techniques: A Handbook for College Teachers. San Francisco, CA: Jossey-Bass, Inc.

Jan 29 (in class)

Bloom (1954) *Taxonomy of Educational Objectives.* NYC, NY: Longman.

Feb 5

Bransford *et al.* (2000) *How People Learn: Brain, Mind, Experience, and School.* Washington: National Academy Press. Chpt 3, p. 51. http://www.nap.edu/openbook.php?record_id=9853&page=R1

Feb 5 (In class)

Woodin et al. (2010) Vision and Change in Biology Undergraduate Education, A Call for Action—Initial Responses. CBE—Life Sciences Education. Vol. 9, 71–73.

Brownell, Freeman, Wenderoth, & Crowe. (2014) *BioCore Guide: A Tool for Interpreting the Core Concepts of Vision and Change for Biology Majors.* CBE—Life Sciences Education Vol. 13, 200–211, Summer.

ACS Program Recommendations (2008)

A Framework for K12 Science Education. (2011) NRC. Chpt 4 + Core concepts of your discipline.

Feb 12 (Reference)

National Research Council, Committee on Undergraduate Science Education (1997) *Science Teaching Reconsidered.* Chpt. 2 How Teachers Teach, Specific Methods – Lectures. Washington, DC: National Academy Press.

http://www.nap.edu/catalog.php?record_id=5287

Feb 19 – Evaluation of College Textbooks.

Eddy & Hogan. (2014) Getting Under the Hood: How and for Whom Does *Increasing Course Structure Work?* CBE—Life Sciences Education Vol. 13, 453–468, Fall.

Feb 19 (In class)

Definitions of critical thinking

- http://www.criticalthinking.org/pages/defining-critical-thinking/410
- http://en.wikipedia.org/wiki/Critical_thinking
- http://www.criticalthinking.net/definition.html
- Helping College Students Read

Feb 26

Gijbels, Dochy, & Van den Bossche (2005) *Effects of Problem-Based Learning: A Meta-Analysis From the Angle of Assessment*. Review of Educational Research, Vol. 75, No. 1, pp. 27–6.

Linton, Farmer, & Peterson (2014) *Is Peer Interaction Necessary for Optimal Active Learning?* CBE—Life Sciences Education Vol. 13, 243–252, Summer.

Mar 12

Herman (1998) Inserting an Investigative Dimension into Introductory Laboratory Courses. J Chem Ed 75, (1) pp. 70–72

Mar 12 (In class)

Montell (2003) *How to Write a statement of Teaching Philosophy*. Chronicle of Higher Education. 3/27/2003.

NRC. (1996) Essential Features of Classroom Inquiry from Inquiry in *Inquiry in the National Science Education Standards*

Types of Laboratory and Inquiry Experiences.

Mar 19

US Department of Education. (2010) Evaluation of Evidence-Based Practices in Online Learning A Meta-Analysis and Review of Online Learning Studies, Means et al.

Mar 26

Johnson, Johnson, & Smith (2000) *Cooperative Learning.*

Beichner & Saul (2003) Introduction to the SCALE-UP (Student-Centered. *Activities for Large Enrollment Undergraduate Programs) Project*. Proceedings of the International School of Physics - Enrico Fermi, Varenna, Italy, (July 2003).

Smith & Tanner (2010) The Problem of Revealing How Students Think: Concept Inventories and Beyond. CBE Life Sci Educ 9(1): 1-5**.**

Smith, Trujillo, & Su. (2011) *The Benefits of Clickers in Small-enrollment Seminar-style Biology Courses.* CBE—Life Sciences Education, Vol. 10, 14–17.

Kracjik & McNeill. (2007) *Instructional Model for Scientific Explanations.* NSTA Journal, March 30.

Apr 2

Tamar Lewin. (2013) *After setbacks, online courses are rethought.* http://www.nytimes.com/2013/12/11/us/after-setbacks-online-courses-are-rethought.html?nl=todaysheadlines&emc=edit_th_20131211&_r=0

AFT on MOOCs. (2014) pp. 1-18.

Griffiths et al. (2014) Interactive Online Learning on Campus: Testing MOOCs and Other Platforms in Hybrid Formats in the University System of Maryland. ITHAKA S+R.

Means et al. (2010) Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. Report for U.S. Department of Education.

Useful resources

MSU Handbook for Teaching Assistants, http://www.msu.edu/~taprog/resources/handbook2002/

NRC. (2015) *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering*. http://www.nap.edu/catalog/18687/reaching-students-what-research-says-about-effective-instruction-in-undergraduate

Final Project

You will work with a partner to write a syllabus for a course. In addition, each of you will write a lesson plan for the same course. You will teach a portion of one of the lesson plans to the class on April 23 or May 3. The written project is due May 3. For more details, see the Final Project Guidelines.

Teaching Portfolio

You will put together a teaching portfolio that documents your teaching experience to date as well as your teaching philosophy. It should also be organized so that you can easily add artifacts from additional experience. The teaching portfolio is due May 3. For more details, see the Teaching Portfolio Guidelines.

Grading

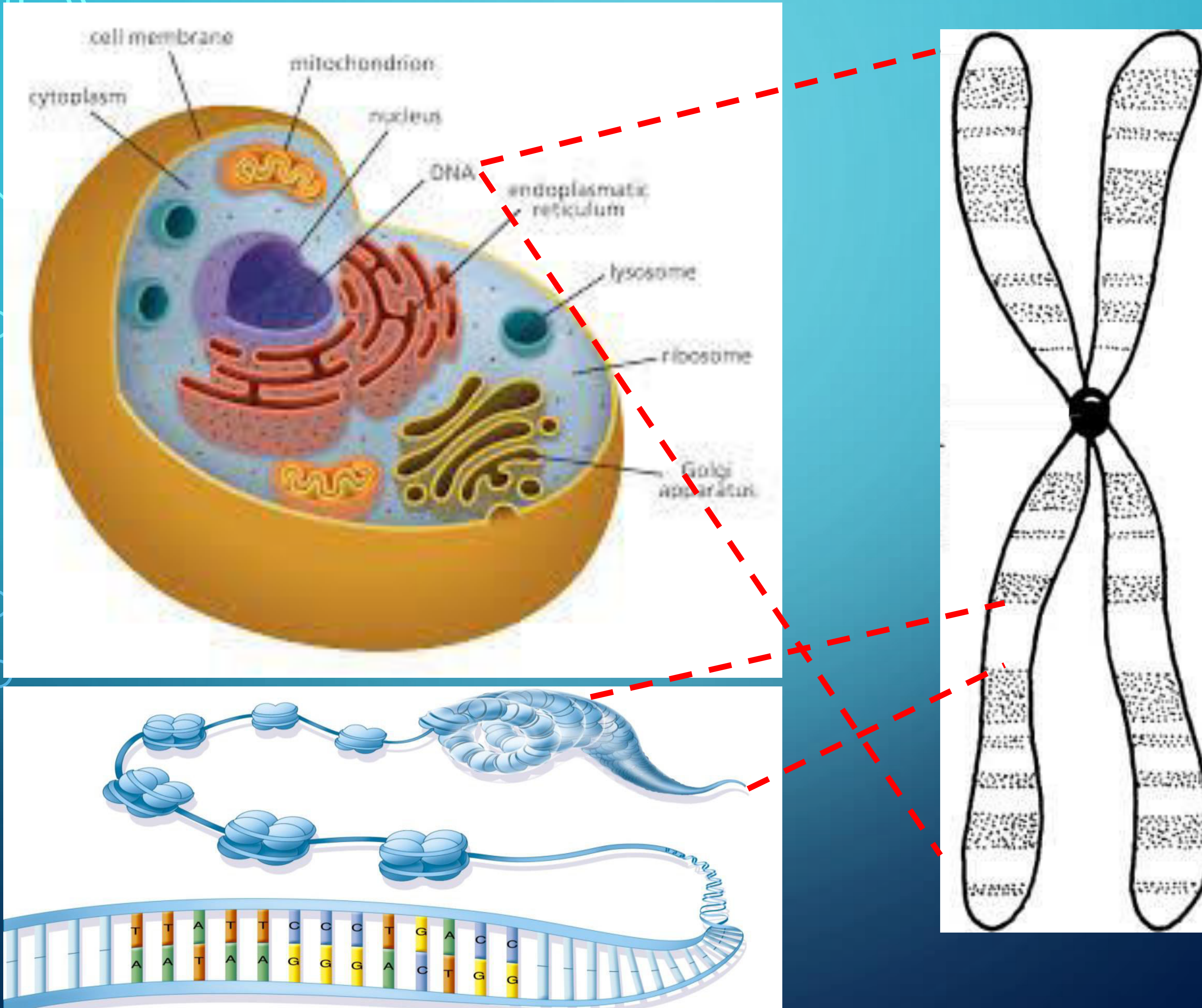
This course is graded on a pass/no pass basis. Requirements for a passing grade are:

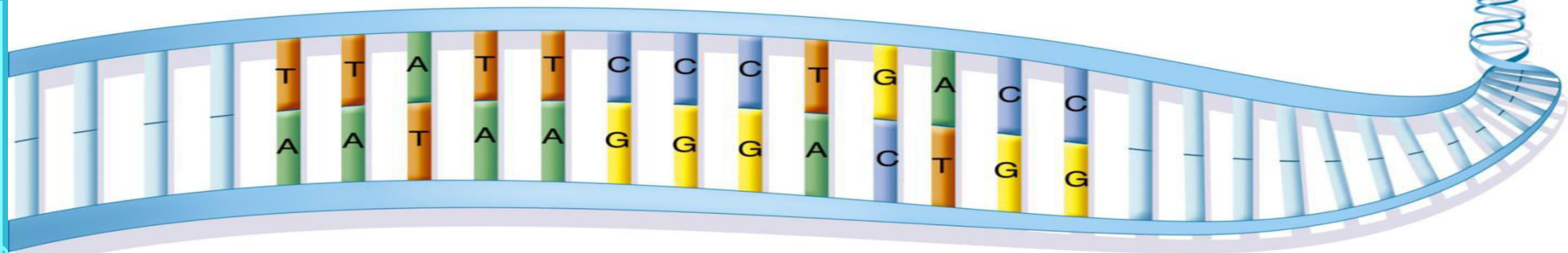
- regular attendance and participation in class including mini-lectures (if you must miss a class session, please contact me ahead of time about makeup work.)
- completion of class assignments including the final project and teaching portfolio.

TOOLS IN MODERN GENETICS: APPLICATIONS AND MECHANISMS

MITCH ROTH

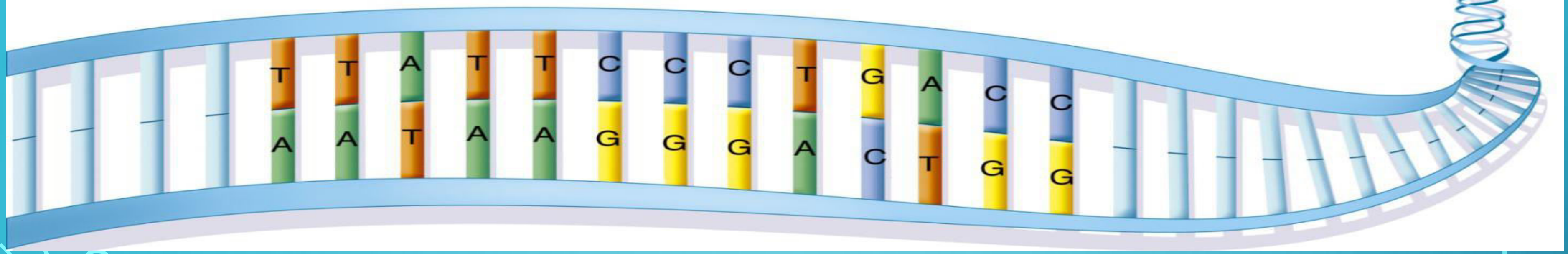
2/12/2018


cell membrane
mitochondrion
cytoplasm
nucleus
DNA
endoplasmatic reticulum
lysosome
ribosome
Golgi apparatus



Few differences

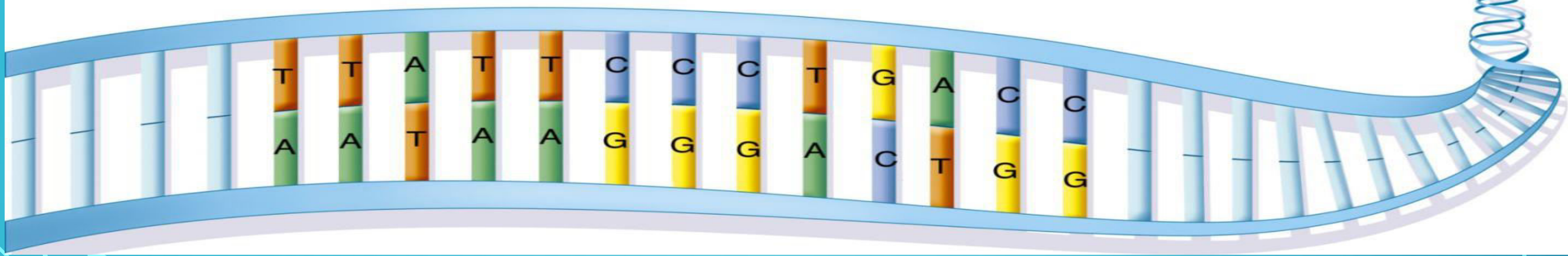
Sisters



One major gene difference

Holstein

Angus



Many millions of differences

Chicken **T-Rex**

Holstein breed of cattle

- *Bos taurus*
- 3 Gb genome size
- Excellent dairy producer
- Sub-optimal meat quality
- In-tact *polled* gene = horns

- <u>Horned phenotype:</u>
- Dangerous for other cattle
- Dangers for human workers
- Horns often removed via burning (animal cruelty)

Angus breed of cattle

- *Bos taurus*
- 3 Gb genome size
- Excellent meat quality
- Sub-optimal dairy producer
- Non-functional *polled* gene = hornless

- <u>Hornless phenotype:</u>
- Safer around other cattle
- Safer around human workers
- No need for physical removal of horms

Dehorning a calf

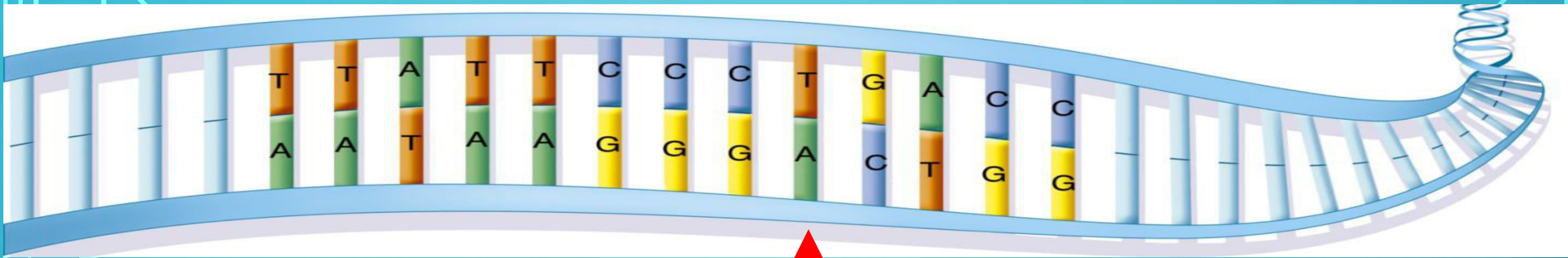
https://www.youtube.com/watch?v=1HRt5rtePOE

Mixed Holstein-Angus cattle

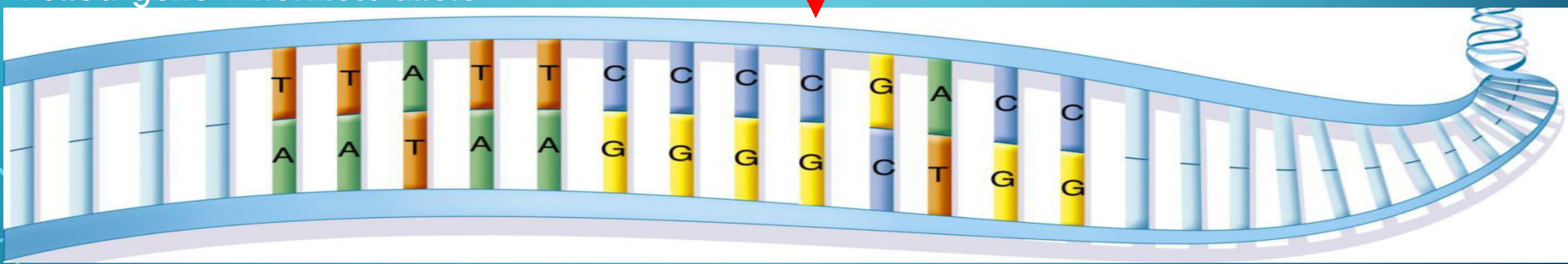
- ***Bos taurus***
- 3 Gb genome size
- Sub-optimal meat quality
- Sub-optimal dairy producer
- 50/50 functional and non-functional *polled* gene

Many generations later…

Polled gene – horned allele



Polled gene – hornless allele



?

What if dogs had horns?

Having horns	Pros	Cons
For the dog		
For pet owners		
For the environment		
For the government		
Others? Please list:		

NEXT WEEK - MECHANISMS

- Restriction enzymes and Ligase
  - "Cut and paste" DNA sequences
- *Agrobacterium tumefaciens* T-DNA transfer
  - Moving DNA from one organism to another
- CRISPR Gene Editing
  - Working with an organism's native DNA sequences

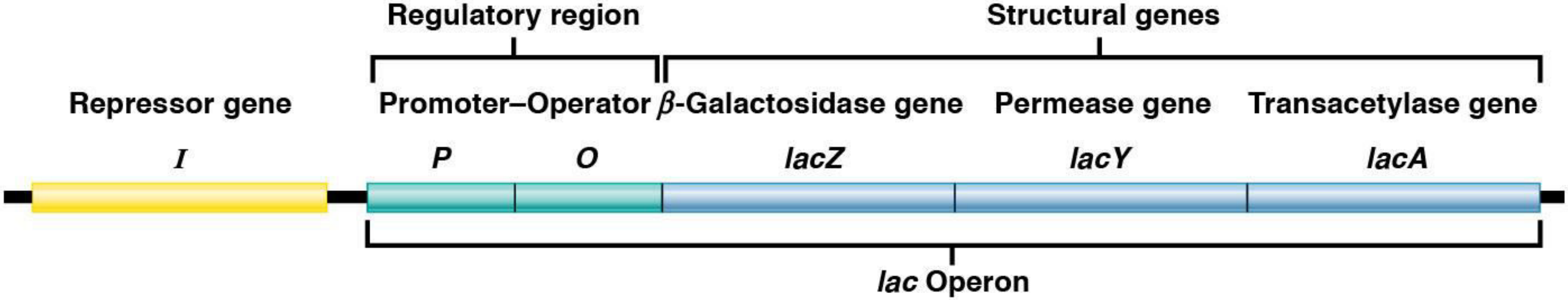
TOOLS IN MODERN GENETICS: APPLICATIONS AND MECHANISMS

MITCH ROTH

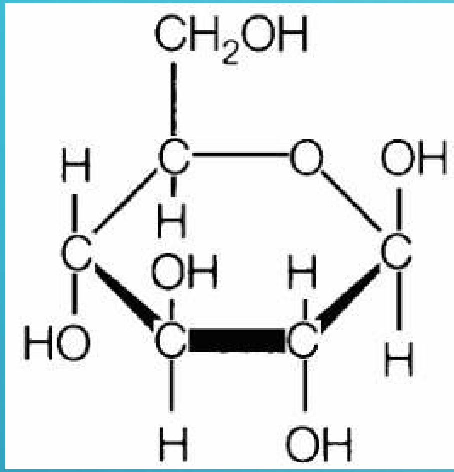
4/9/2018

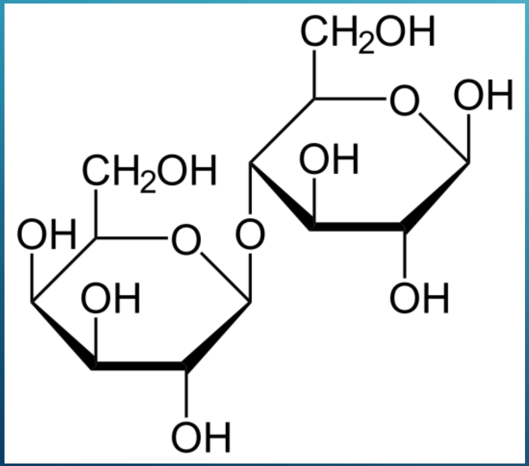
SHOULD ALREADY KNOW

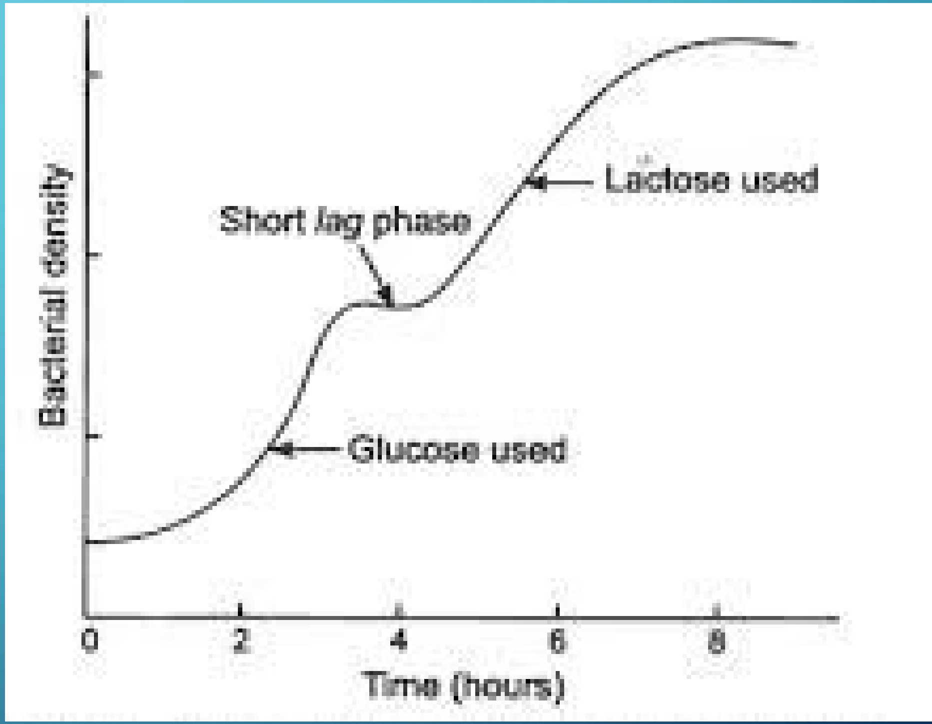
- Central Dogma of Molecular Biology
  - DNA → RNA → Protein
- Types of DNA in bacterial cell
  - Chromosome and plasmids
- Regulation of gene expression in bacteria
  - Lac operon

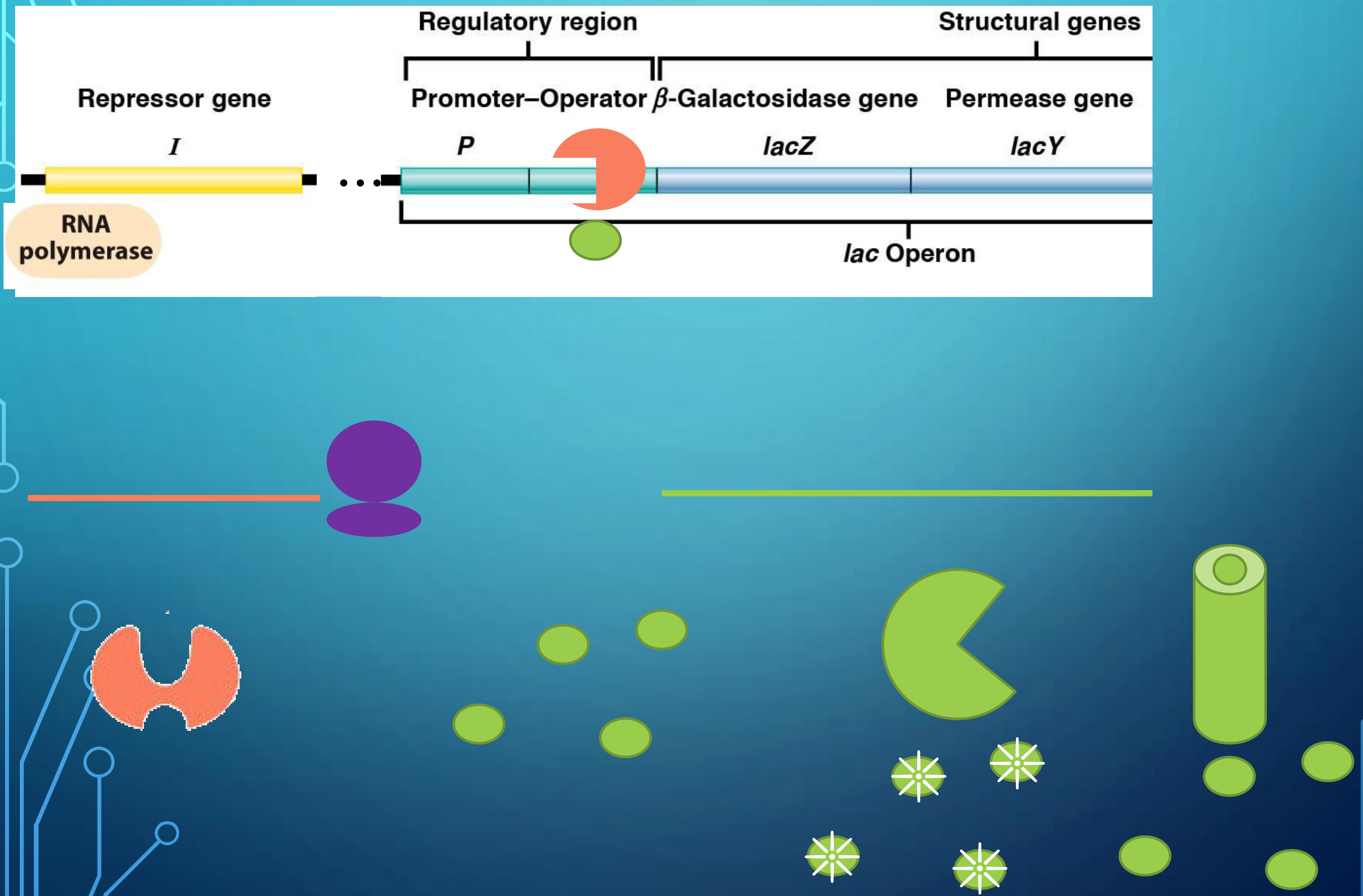


SHOULD ALREADY KNOW









Regulatory region
Structural genes
Repressor gene
Promoter–Operator
β-Galactosidase gene
Permease gene
I
P
lacZ
lacY
RNA polymerase
lac Operon

Table 14.1	*lac* Operon Genes and Regulatory Sequences		
Gene/Sequence	**Product/Sequence Type**	**Function**	**Important Mutants**
Protein-Producing Genes			
lacI	Repressor protein	Contains two binding sites, one for the operator and one for lactose, the inducer	I^-—Unable to bind to operator I^S—Unable to bind the inducer (allolactose)
lacZ	β-galactosidase	Cleaves lactose into two monosaccharides (glucose and galactose)	Z^-—No functional β-galactosidase
lacY	Permease	Facilitates lactose transport across the cell membrane	Y^-—No functional permease
lacA	Transacetylase	Protects against harmful by-products of lactose metabolism	A^-—No transacetylase
Regulatory Sequences			
lacO	Operator	Binds repressor protein to block transcription of operon genes	O^C—Fails to bind repressor protein
lacP	Promoter	Binds RNA polymerase	P^-—Fails to bind RNA polymerase or does so weakly

ACTIVITY – STEP 1

- You have a bag of Lac genes, some are wild type and some are mutated
- Find others that have the same genotype as you, and form a group

ACTIVITY – STEP 2

- Your group is now a pure culture of bacteria, and I have just transferred you into a new flask where lactose is present
- As a group, go through all of the steps to determine if you will express LacZ and LacY and survive!
  - If you will survive, be ready to explain how and why
  - If you won't survive, be ready to explain what you might need in order to survive

ACTIVITY – STEP 3

Group 1	Group 2	Group 3	Group 4
LacI+	LacIS	LacI-	LacI-
LacP+	LacP+	LacP+	LacP-
LacO+	LacO+	LacOC	LacOC
LacZ-	LacZ+	LacZ-	LacZ+
LacY-	LacY+	LacY-	LacY+

ACTIVITY – STEP 3

Group 1	Group 2	Group 3	Group 4
LacI+	LacIS	LacI-	LacI-
LacP+	LacP+	LacP+	LacP-
LacO+	LacO+	LacOC	LacOC
LacZ-	LacZ+	LacZ-	LacZ+
LacY-	LacY+	LacY-	LacY+
Needs	**Needs**	**Needs**	**Needs**
LacZ+	LacOC	LacZ+	LacP+
LacY+		LacY+	


P$^+$
Z$^+$
Y$^+$
F' #1
LacP$^+$Z$^+$Y$^+$


P$^+$
O^c
Z$^+$
Y$^+$
F' #2
LacP$^+$O^{C}Z$^+$Y$^+$


P$^+$
O$^+$
Z$^+$
Y$^+$
F' #3
LacP$^+$O$^+$Z$^+$Y$^+$


P$^+$
O^c
Z$^+$
Y$^+$
F' #4
LacI^s, LacP$^+$O^{C}Z$^+$Y$^+$
I^S

GENOTYPE:	LacI bound to lacO?	CAP bound to promoter?	LacZ and LacY expressed?
Glucose low Lactose low			
Glucose high Lactose low			
Glucose low Lactose high			
Glucose high Lactose high			

NEXT WEEK – APPLICATIONS

- If the Lac operon genes were cloned into another system, would they still work?
- If so, how could we take advantage of LacI, LacP, and LacO?

Genetics and its Applications in the Modern World

Course Overview

Y Hoang and Mitch Roth

5/3/18

Course Objectives

In this course, students will expand the basic knowledge of genetics they attained in introductory biology courses. This will involve learning new terminology and new core concepts. Students will learn about the actual processes that happen in the cell such as DNA replication, gene expression, and explore their applications in various fields of biology (PCR, cloning, regulating gene expression, expressing a of protein-of-interest).

Upon successful completion of the course students should be able to understand and explain the logic and core concepts of molecular genetics and apply this knowledge to solve complex problems, analyze data, and interpret experimental results. The core concepts will include:

- Mechanisms of DNA replication
- Mechanisms of DNA recombination
- Transcription and translation,
- Regulation of gene expression
- Mitosis and meiosis
- Connection between genotype and phenotype
- Mechanisms of genetic engineering
- Genomics
- Determine how mutations affect these processes

Schedule of Topics

Week 1: Review of basic cell biology, physiology, processes and DNA structure and organization

Week 2: Microbial genetics 1 - DNA replication, plasmids

Week 3: Microbial genetics 2 - application of DNA replication → PCR

Week 4: Microbial genetics 3 - Restriction enzymes, ligase

Week 5: Microbial genetics 4 - application of RE → cloning

Week 6: Microbial genetics 5 - gene expression / catabolite repression

Week 7: Microbial genetics 6 - application of gene expression → cloning / overexpression of a gene of interest

Week 8: Review session, EXAM 1

Schedule of Topics

Week 9: Euk. genetics 1: DNA replication, mitosis & meiosis

Week 10: Euk. genetics 2: application of meiosis → prediction of gametes / offspring phenotypes

Week 11: Euk. genetics 3: regulation of gene expression and the cell cycle

Week 12: Euk. genetics 4: application of regulation → metabolic engineering, and cancer genetics

Week 13: Euk. genetics 5: genomics

Week 14: Euk. genetics 6: application of genomics → GWAS and marker-assisted breeding

Week 15: Review session, EXAM 2

Week 16: Final Exam

Grading

Category	Percent of Grade
Attendance	5%
Problem sets	20%
Midterm Exam 1	25%
Midterm Exam 2	25%
Final Exam	25%

- Attendance will be monitored by participation in clicker points. If a student uses someone else's clicker to earn attendance points for that student, this will be considered academic dishonesty which can result in a failure of the class and/or expulsion from the university. If a student is present for 90% or more of the lectures, the student will receive 100% for the attendance portion of their grade.

- Problem sets will be assigned in class and collected in class 1 week after being assigned. The assignments will be graded and returned to the students 1 week after being turned in.

Concept: DNA Replication
Application: Polymerase Chain Reaction

•••

Genetics and its Applications in the Modern World
5/3/18

Clicker Questions

What does DNA stand for?

A. Dithiothreitol naphthalic acid
B. Deoxyribonucleic acid
C. Dimethylsulfoxide nitric acid

Clicker Questions

Where is DNA found in a cell?

A. Mitochondria
B. Ribosome
C. Golgi Apparatus
D. Nucleus

Clicker Questions

What organelle is “1”?

A. Mitochondria
B. Ribosome
C. Golgi Apparatus
D. Nucleus

Discussion Questions

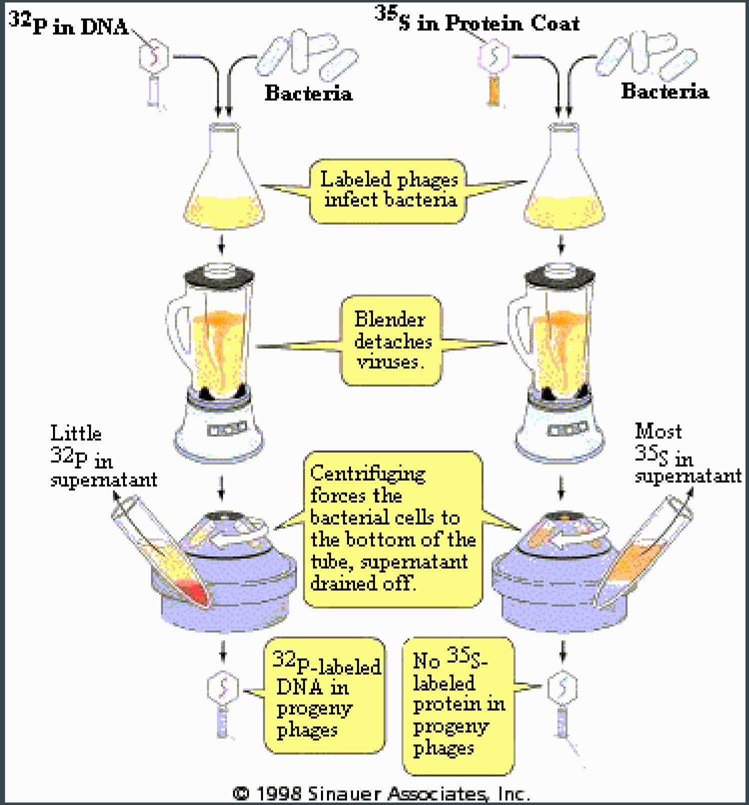
Why is DNA important?

What does DNA do?

How did we figure out what it does?

How did we get here?

How did we come to know DNA is so important?



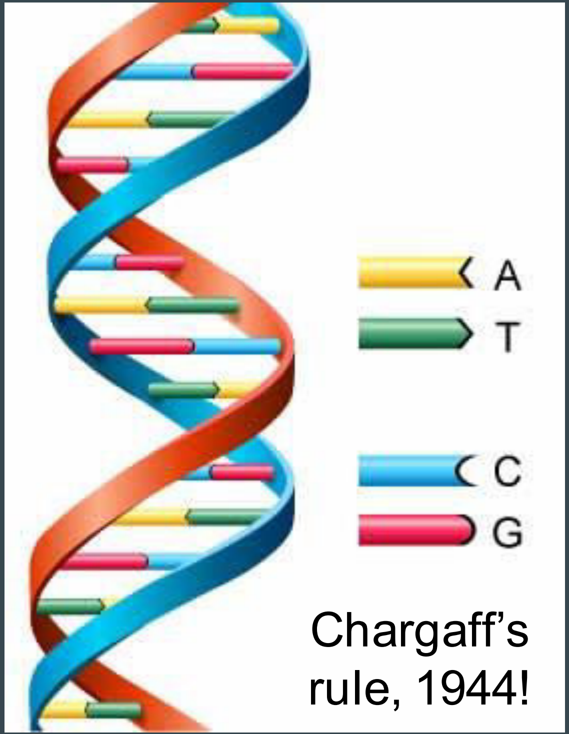
How did we get here?

If DNA “codes” for life, what does DNA look like?

James Watson

Francis Crick

Rosalind Franklin



Chargaff’s rule, 1944!

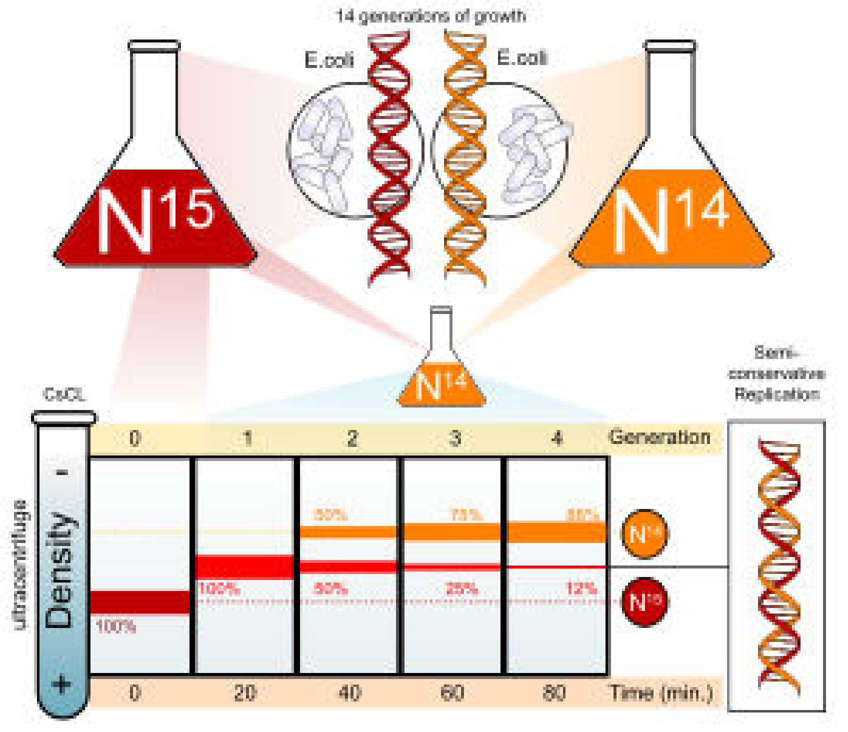
Activity

Make your own DNA model

- “Twizzler” backbone of DNA
- “Gummy bear” base pairs
- “Toothpick” hydrogen bonds
- Be sure to follow Chargaff’s rule!

How does it work?

If DNA “codes” for life, how does it propagate and ensure that life goes on?



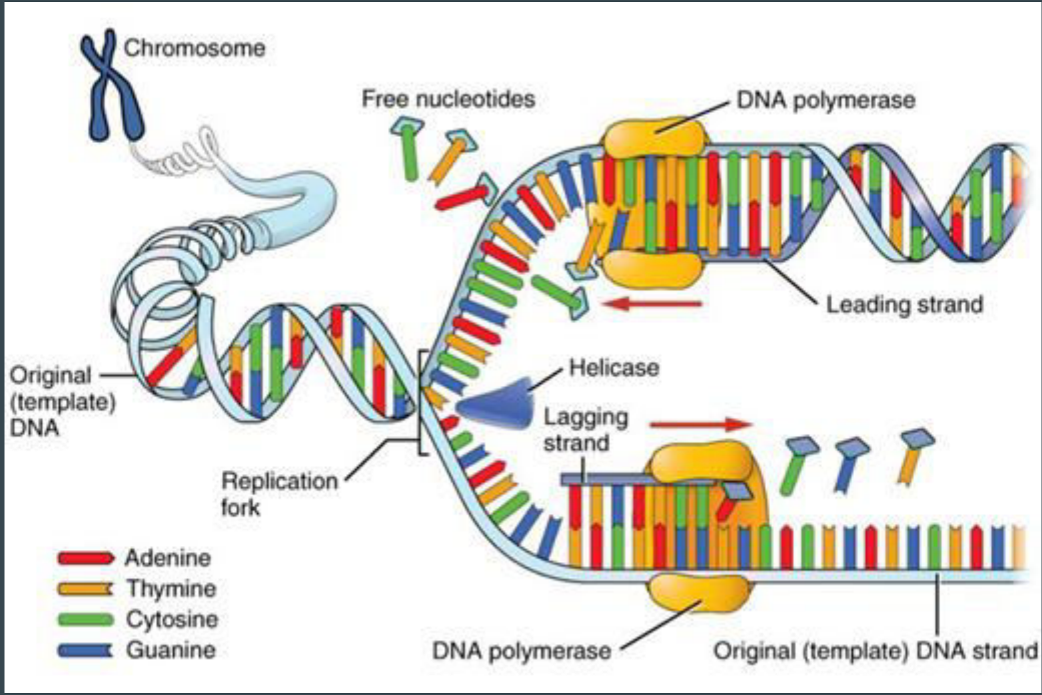
1958

Meselson and Stahl showed that DNA is replicated by taking advantage of the two strands

- A pairs with T
- C pairs with G
- One strand used as template (radioactive)
- New strand is synthesized (not radioactive)
- Two, double stranded DNA molecules, both with 1 radioactive strand and one non-radioactive
- Four, double stranded DNA molecules, two as above, and two with no radioactive strands

How does it work?

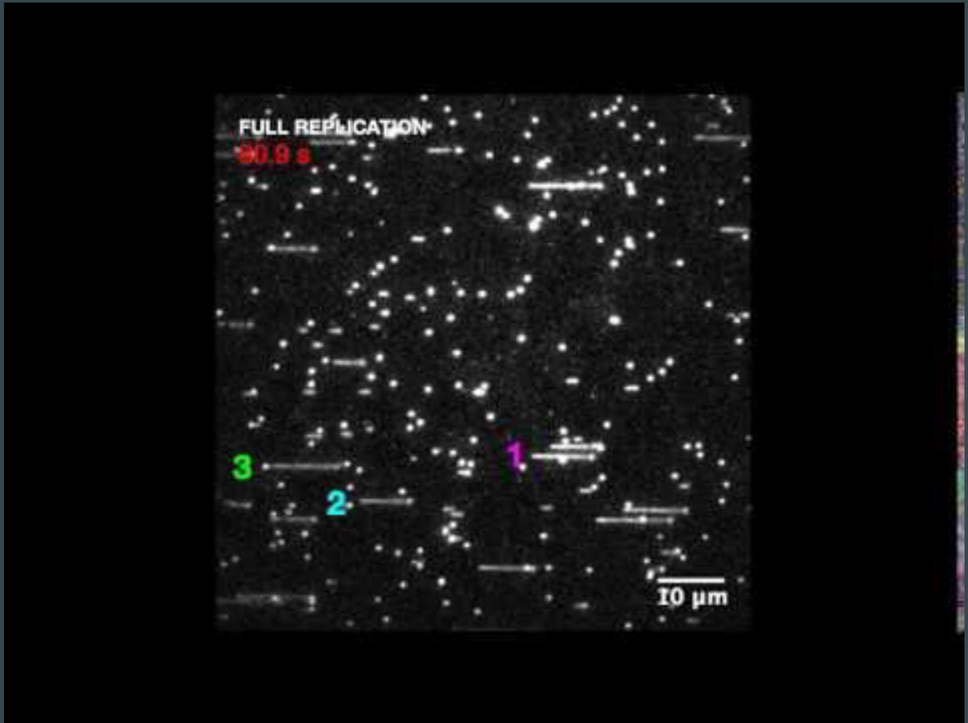
If DNA is “replicated” how does that work?



DNA Replication

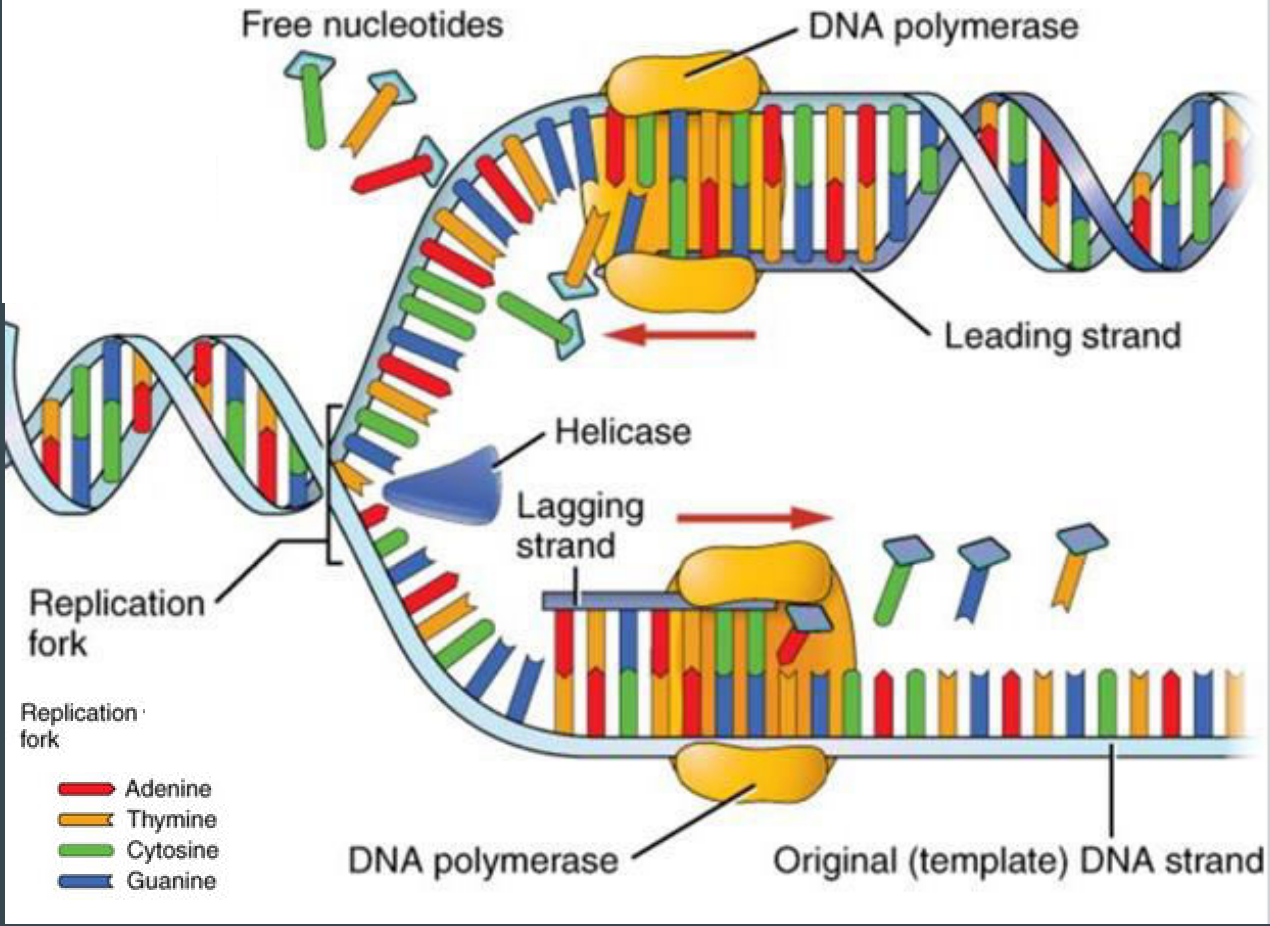
This is still an active area of research!

Graham et al 2017. Independent and Stochastic Action of DNA Polymerases in the Replisome. *Cell*. https://doi.org/10.1016/j.cell.2017.05.041



Replication

1. Helicase unwinds DNA
2. Primase (not pictured) adds “primer” - small string of nucleotides
3. Polymerase uses primer to continue synthesizing complementary strand of DNA
4. Gyrase (not pictured) prevents over-twisting
5. Topoisomerase (not pictured) fixes over-twisted DNA
6. Ligase (not pictured) fixes any DNA breaks



Taking Advantage of DNA Replication

DNA is small. I mean, really small. Consider a single gene that is 100 nucleotides long:

```
ATGATGAGACCACAGACTAGAACGAATATATTACCGAACTGACGCTGACGCTACGACGATGATGCCGATCGATCGATCGATCGTACGCGCGATCGTACGT
TACTACTCTGGTGTCTGATCTTGCTTATATAATGGCTTGACTGCGACTGCGATGCTGCTACTACGGCTAGCTAGCTAGCTAGCATGCGCGCTAGCATGCA
```

- How can we get enough DNA to work with?
- Polymerase chain reaction

- This gene (both strands) weighs 1.023965825e-16 micrograms
- You would need 10 quadrillion (1×10^{16}) strands of the gene to get 1 microgram!
- You need 1 million micrograms to have 1 gram of DNA!

Polymerase Chain Reaction

Polymerase chain reaction (PCR) is a technique used in molecular biology to amplify a single copy or a few copies of a segment of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.

1. The two strands of the DNA double helix are physically separated at a high temperature in a process called DNA melting.
   a. What separates DNA during replication?
2. The temperature is lowered and the two DNA strands become templates for DNA polymerase to selectively amplify the target DNA.
   a. What tells Polymerase where to begin?
3. Polymerase synthesizes a complementary strand of DNA using a template strand
   a. What does Polymerase build DNA with?

Polymerase Chain Reaction

Virtual lab:
http://learn.genetics.utah.edu/content/labs/pcr/

Next Week

How exactly does DNA “code” for life?

- Genes / gene expression
- Transcription and Translation
- Cloning

Homework:

- Crossword Puzzle
  - http://www.nclark.net/Genes_Crossword.pdf
- Paper to read
  - https://www.annualreviews.org/doi/pdf/10.1146/annurev.biochem.71.110601.135425