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Student Teaching Practicum: Sophomore Biology at Wachusett H.S.

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STUDENT TEACHING PRACTICUM:
Sophomore Biology at Wachusett Regional High School

Interactive Qualifying Project

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Chapter 1 – Wachusett Regional High School At A Glance

Wachusett Regional High School is a fairly large school located in the fairly small town of Holden, MA. As its name indicates, WRHS is a regional high school with enrolled students living in Holden, Paxton, Princeton, Rutland, and Sterling, all towns in Worcester County. Sixty years ago, each of the five towns provided secondary education for the youth of their own towns, but in 1955 the regional high school was founded. This structure allows the towns to pool their monetary and other resources, and to also receive further federal funding. Because the towns are all suburban or bordering on what could be considered rural communities with very small populations, it was much more affordable to staff and outfit a large high school over five small high schools. Since that time, the Wachusett Regional High School has gained much respect and acclaim in the academic community as a public school which unites the communities of five towns and provides students with an outstanding education.

In order to understand the community within the walls of the high school, it is important to understand the communities which its members are part of in their own respective towns. Table 1.1 contains information regarding the population size and demographics of the communities. As can be seen, Holden is by far the largest of the towns which most likely explains why it is the location of the WRHS school building. Because Holden is at least twice as large (if not five times as large) as each of the other towns, it easily has a larger number of minority citizens. Princeton, however, has the largest percentage of different races and ethnicities though it is the smallest of the towns. Despite some differences, most of the towns fall into a relatively close range of diversity level, and so when students arrive at WRHS from their respective middle schools they

should not feel unused to the level of diversity which will meet them in the school halls. Combined census information from the five towns can be seen in Table 1.2 which shows that at 97.1%, most of the citizens of the five town are white, and that Hispanic or Latino individuals make up the greatest minority group at 1.2% of the five-town population.

While cultural factors do play a role in the classroom, there are other factors which should be taken into account when stepping into a teaching role. One of these factors is the household structure which students are used to. The data show that almost one out of every ten children in the five towns is living in a single-mother household. This factor could affect the amount of parental support and family structure these children experience.

Table 1.1: Demographics for Five Towns[1]

		Holden	Paxton	Princeton	Rutland	Sterling
Total Population		16,621	4,386	3,353	6,353	7,257
# 15-19	#	1,080	409	253	441	430
	%	6.9	9.3	7.5	6.9	6
White	#	15,214	4,241	3,244	6,136	7,116
	%	97.4	96.7	96.7	96.6	98.1
African American or Black	#	103	30	10	66	52
	%	0.7	0.7	0.3	1	0.7
Asian	#	154	47	32	29	29
	%	1	1.1	1	0.5	0.4
Hispanic or Latino	#	160	68	49	84	59
	%	1	1.6	1.5	1.3	0.8
# Two or more races		124	39	35	85	42
% Single-mom households		10.8	6.5	6.5	12.3	9.2

[1] *Commonwealth Communities*, http://www.mass.gov/?pageID=mg2terminal&L=3&L0=Home&L1=State+Government&L2=Local+Government&sid=massgov2&b=terminalcontent&f=cc_landing&csid=massgov2

Table 1.2: Regional Demographics[2]

Total Population		**37970**
# 15-19	**#**	**2613**
	%	**7.3%**
White	**#**	**35951**
	%	**97.1%**
African American or Black	**#**	**261**
	%	**0.7%**
Asian	**#**	**291**
	%	**0.8%**
Hispanic or Latino	**#**	**420**
	%	**1.2%**
# Two or more races		**325**
% Single-mom households		**9.1%**

A great deal of information is available about the demographics and other data regarding the students of WRHS due to Massachusetts Board of Education mandates and research incentives. Total enrollment at WRHS for the 2007-2008 school year is 1,905 students. When comparing the number of high school-age children in the region to the total enrollment at WRHS, is becomes obvious that 708 eligible students in the region are not attending WRHS. This number can be explained by the fact that there are several private schools in the area. Information about which citizens and their ethnicity are unavailable for private schools which do not need to disclose their enrollment data to the public, but one can see the impact on diversity at WRHS comparing the regional populations to the WRHS populations. Table 1.3 clearly shows that diversity at WRHS is somewhat higher than that of the surrounding community.

[2] *Wachusett Regional High - Enrollment/Indicators*, http://profiles.doe.mass.edu/home.asp?mode=so&so=2318-6&ot=5&o=2306&view=enr

Table 1.3: Comparative Demographics[3]

	Region	WRHS
# 15-19	2613	1905
% White	97.1%	96.2%
% African American or Black	0.7%	0.9%
% Asian	0.8%	1.0%
% Hispanic or Latino	1.2%	1.5%

While any educator should have some awareness on cultural diversity in their school, diversity is not a major factor in classrooms at WRHS. As Figure 1 demonstrates, even the three most prevalent minority groups at the school are extremely small when compared to the overwhelming white population. While there are races besides those mentioned in Tables 1.1-3, the "other" section of the graph in Figure 1.1 demonstrates visually and numerically how small the range of races is at WRHS.

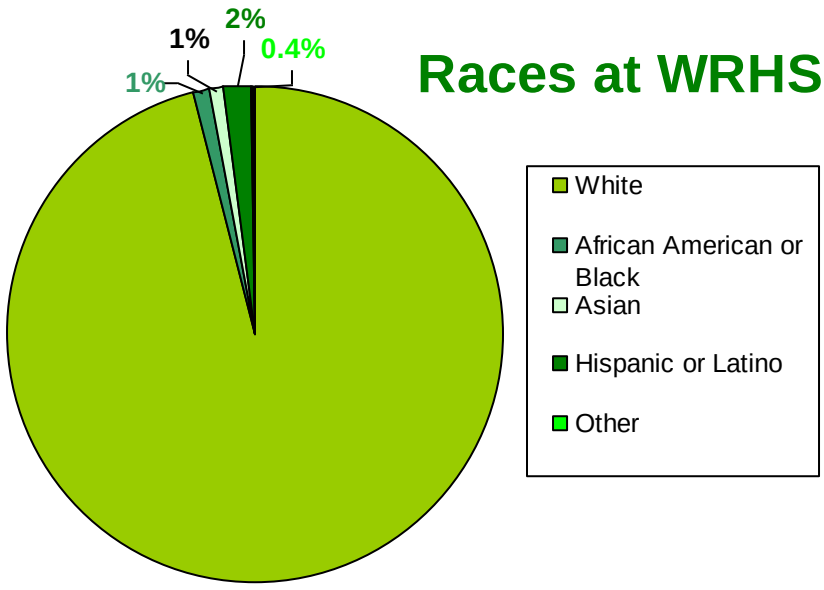

Figure 1.1 Races at WRHS[3]

[3] *2006-2007 Report Card - Wachusett Regional High*, http://www.wrsd.net/highschool/top%20bar%20links/district.html (Sept 2007)

Perhaps the most direct impact of diversity in schools is attendance by students who speak English as a second language (ESL). School studies show that only 8 students out of the 1,905 speak English as a second language. This means that there are relatively few language barrier issues at WRHS when compared to other schools in Worcester County (including Worcester schools in particular).

Aside from cultural diversity, economic diversity is an additional factor which instructors must be aware of. Family income can factor into a student's life in several ways, including available technology at home, ability to afford school supplies, medical attention for any health or behavioral concern, and even a student's view towards the range of colleges which they an aspire to attending or various social barriers which students create. Research done by the district shows that there will be 92 students from low-income families attending WRHS in the 2007-08 school year. This constitutes about 5% of the student body, and means that there is a chance that each classroom of 20 students could include one individual from a low-income family.

On the opposite end of the spectrum, most families are fairly well-off, with an average household income which reaches above the state average. The affluence of the area is reflected most directly in the school facilities themselves. The school is currently in the final stages of a three-phase construction project which includes the addition of an entire arts wing, the building of new athletic fields, and the renovation and refitting of many academic rooms including science lab classrooms. The project is expected to be finished in November of 2007. This project reflects not only the commitment to education, but the fiscal capabilities of the towns which support the high school.

While there is relatively low diversity among the student body, the academic programs at WRHS certainly cater to a diverse range of interests and capabilities, and the wonderful new school building is not the only feature which WRHS has to brag about. The school's teacher to student ratio is 13.7:1, and many teachers' aides work within classrooms to help the school's 158 special education students. Of the 139 teachers 96.6% are considered by the state to be "highly qualified," and 20 teach elective classes in topics outside of core academic areas. This includes arts, technology, life skills, and health classes. The school has fantastic technological resources, and boasts 1 computer for every four students, with internet availability in virtually all classrooms. The WRHS dropout rate of 0.4% is far lower than the state's 3.3%, as well as the absentee and suspension rates. 72% of students who do graduate move on to 4-year colleges, and 15% attend 2-year colleges or other post-secondary schools. The academic departments offer excellent and diverse programs for students, and this commitment to excellence shines through in the results of standardized tests results, the long list of colleges which accept WRHS students, and the wide recognition the school's students have received.

It is not surprising that WRHS students out-perform the state averages on MCAS testing. Table 1.4 contains the percentages of students in each grading level for the MCAS in 2006. While performance was clearly stronger on the mathematics exam, both sets of test results speak well of the school's programs. When compared to performance of all high schoolers across the state, WRHS students certainly stands above its fellow schools.

Table 1.4: WRHS MCAS scores for 2006[4]

	Advanced	Proficient	Needs Improvement	Failing
English Language	25	58	15	3
Mathematics	54	27	14	5

In addition to classes during the day, WRHS students participate in a wide range of extra-curricular academic and other activities in which they have been very successful. The Science Seminar program is an excellent example. Students apply to participate in a program which brings local experts on scientific topics to speak to them after school once a week, and to help them with year-long science projects of their choice and design. At the end of the year, the school holds a science fair, and winners in the past year have moved on to regional and national science competitions. The arts are also very strong at WRHS, where the new music and arts wing houses the Grammy-recognized marching band which was invited to perform in Disney World in 2007. The school's theater students have also won awards for their school this past spring, where they won several awards in the MHSDC One-Act Festival State Finals. WRHS students also shine on the new athletic fields, with several teams winning championships and a "Badlands" cheering section of dedicated super-fans.

While this is only a brief overview of WRHS, the community which supports it, and performance of students, it allows for an accurate impression of the school. The five-town region, with its low diversity but ample monetary funds, supports a school which provides its students with diverse programs of study, and excellent facilities and teaching

[4] *Annual Comparisons for Wachusett Regional High – Wachusett*, http://profiles.doe.mass.edu/mcas/mcascharts.asp?mode=so&view=tst&ot=5&o=2306&so=2318-6&school=775505&mcasyear=2006 (Sept. 2007)

staff. Tests such as MCAS vouch for the relative success of this high school in providing students with a strong academic background.

Chapter 2 – The Courses at Hand

In US public schools there are very clear guidelines about the skills, principles, and knowledge which students should be learning which each state education department has set. In Massachusetts, these guidelines are contained in the Curriculum Frameworks. The state has created a set of frameworks for each discipline taught in schools which include all topics which should be studied and at what grade-level they should be introduced. WRHS has used these frameworks as a guideline for creating the courses provided within the science department, and has also created the means for students with different abilities to learn at their own level. The ultimate goal of the system is to provide students with a high school education which will prepare them for their lives as adults.

Before students at the high school can be enrolled in specific classes, they are identified as felling within a specific learning level. Any teacher would agree that within any age or grade-level, one will find students with different academic abilities and maturity levels. While some school systems have found ways to cater to all students' needs within a single classroom, most American schools have adopted some form of class levels or tracks. At WRHS, there are four main "tracks" which students may follow through their four years of high school. These different leveled classes allow teachers to use specific instruction skills which will be most beneficial to the students and assign work which all students can handle. This system also prevents a few students from being over- or under-challenged in the classroom. Though I only taught classes from two of the levels I found it important and useful to understand the overall structure of the level system, and to recognize what distinguished the levels I was teaching from the others.

For "average" students, WRHS has created the Academic Enrichment (AE) track. These classes are for students who have a difficult time with the discipline, and require a fair amount of time to master concepts. These classes provide ample in-class time for review of topics and practice with new skills. Teachers provide ample individual support to students, and assign little homework. It is not uncommon for this level to include students with Individual Educational Plans (IEP), but they make up the minority of these classes.

The Academic Foundation (AF) is a more challenging level than AE, and is designed for students who are "above average." Teachers use a more challenging teaching style with these students, and lead students on a more in-depth look at the topics. These students are expected to take on some outside research projects, and should be more responsible for practicing and reviewing lessons outside of the classroom.

The most challenging classes at WRHS fall into the Honors level. These are quick-paced classes for "exceptional" students which provide a challenging, detailed look at the discipline. Students are expected to take on a great deal of outside work, and are often more motivated and independent than students in other levels. All students in honors science classes must complete a large year-long project outside of the classroom. While they receive help from their teachers, these students must independently design, complete, and analyze science experiments. Honors students should make up the smallest percentage of students in any grade-level, and so the classes usually contain fewer students.

The V level sits at the opposite end of the spectrum. This level is only for students with IEPs. There are often several teachers aides to provide teaching assistance.

These students are taught at a slower rate, and are expected to do very little outside work or practicing. Teachers of these classes must have good class management skills, and must design courses to be extremely individualized to each student's abilities. There is only one level V course in the science department, and this course is called "Science Explorations." Students in this class stay with the same classmates and teacher for three years. This program is meant to allow students to stay with teachers who they have learned to respect, and who understand individual students' needs. This is the only level which is not considered to be a college preparatory level.

Once students have been organized into different levels, they must be entered into a science class which is appropriate to their grade-level. The world of science can be separated into several different disciplines. The Massachusetts Department of Education has separated science for pre-kindergarten through high school student into four different strands: Earth and Space Science, Life Science, Physical Sciences, and Technology/Engineering. WRHS students study the latter three, and follow a specific sequence. All students enrolled in college-prep courses begin with physics as freshmen. They then move onto biology as sophomores. Most juniors move on to a year of chemistry, but some may choose to take one of several elective science courses which fall in the AF or AE level. Others may take chemistry, then one or more of the electives for only their senior year. An Honors Physics class is also an option for upperclassmen. Students who wish to take more challenging courses after they finish chemistry have the opportunity of moving on to AP Biology or Chemistry. Advanced Placement (AP) courses are designed to mimic college classes, and require a great deal of skill and work.

Depending on the grade which students earn on their AP exams, they may be able to receive college credit for these courses.

The three major classes in physics, biology and chemistry fit into the Life and Physical Science strands which the state requires; and a range of elective science classes enhance the study of these disciplines should students opt to take them. Additionally, an Engineering in Physics course falls into the Technology/Engineering strand. Because students are required to take at least three years' worth of science (some opt for four years' worth or more), all WRHS students leave with a solid background in the main disciplines of science. There is also a strong focus on having mathematical skills as students move through the classes. Grades in eight grade math help to determine which physics class students will be entered into. Mathematical concepts are then used in each of the three main science classes, and several of the elective courses.

While it may seem as though students switch between these different strands, a closer look at the content of each course contradicts this assumption. For example, the sophomore biology courses which I taught drew from the physics which students had taken the previous year and also set the stage for concepts which my students would learn the following year in chemistry. In providing evidence which supports the Big Bang Theory I asked my students to recall what they had learned about light waves in physics, since scientists use this knowledge to tell if stars are moving towards or away from us. While physics is not an integral part of many concepts in biology, the biology teachers at WRHS try to relate back to physics as much as possible. The biology class also helped to prepare my students to take chemistry as juniors. Because it is essential to understand several basic chemical principles when studying certain biological processes, there are

lessons during which biology students spend a considerable amount of time learning about chemistry. For example, to learn about the "building blocks" of organisms biology students must examine the basic types of molecules, how they bond together, and how they behave. This clearly sounds more like a chemistry lesson than a biology lesson. Once students move on to chemistry they will surely draw on their elementary chemistry lessons in biology class, as well as their knowledge of physics when learning more about light and nuclear physics.

Mathematical skills can also easily be traced through the courses. In physics, the students use equations to explain the laws of motion and thermodynamics. In biology, my honors students had to use foiling techniques from algebra to understand Mendel's principles of heredity and the probability of inheriting various traits. My AE biology class used ratios and multiplying fractions to answer similar problems. Once my students move on to chemistry they will have to calculate concentrations in solutions, and the honors students will use math to relate different types of energy.

The elective courses draw even more directly from the classes within the mandatory sequence. Classes such as Human Biology, Plant Biology, Environmental Science, Natural History of New England, and Introduction to Biotechnology all clearly draw from the biology class which all WRHS students take as sophomores. The elective Engineering Physics draws directly from the freshman physics class, and a class in Forensic Sciences requires a foundation of chemistry skills along with some biology. As a student teacher I was fortunate to be teaching a discipline which was drawn upon in the greatest amount of electives, and so I knew that students would have many opportunities to apply what I taught them to later courses.

While specific knowledge in one science course may relate to the other courses at some points, there are still many lessons in each discipline which are independent of the others. One could argue that the true "strands" which run through students' science education is not related to specific knowledge, but rather basic science skills. In a careful inspection of the WRHS course catalog, it is often the description of skills which must be learned or "approaches" which students learn to take towards science which are repeated over and over again in describing different courses. These components can be broken down into four areas: developing problem-solving skills, learning and applying the scientific method, gaining lab experience, and completing projects.

Each of the core subjects taught in high school (English, history, foreign language, science, and math) require problem-solving skills. Science certainly depends on this ability as the driving force behind all discovery and innovation. Teachers introduce problems in different ways depending on grade-level and area of science. Freshman physics students "play" toy cars in order to identify the laws which govern movement. Biology students are faced with a new biological process and, with direction from teachers, explore possible explanations until they determine the basic mechanism. Chemistry students are provided with the specific reactants of an experiment, and asked to predict not only the products, but the amount produced. These are specific examples, but they each show how problem-solving skills are developed within each discipline. They also show how students are able to tackle more difficult and complex problems in each discipline as they progress. This is not because each discipline is harder than the last, but because they are taught at a higher level according to the students' skills.

As students learn the spirit of scientific inquiry, they are taught to understand the value and applications of the scientific method. This is a sequential approach to identifying and examining a problem, making preliminary hypotheses, testing this prediction, and drawing conclusions from the outcome of the testing method. As students solve problems such as those described above, they are encouraged to apply the scientific method to the problem at hand. Students learn about the importance of the scientific method while learning about historical scientists and how they developed the laws and principles which we still study today. Honors students literally take the scientific method home with them when they take on a year-long science project. This project requires students to come up with a problem, form a hypothesis, identify important variables, and design an experiment to test their hypothesis. Each year these experiments are expected to be increasingly sophisticated as students demonstrate their increasing comfort with the scientific method.

For many science teachers, the most enjoyable lessons to teach are those in which students experience first-hand the principles they have learned. This laboratory experience often provides the most memorable and effective for students, and the techniques learned are an extremely important learning tool. Because WRHS has outstanding facilities and resources, the teachers are able to provide students with ample opportunity to learn several important lab techniques. As freshman, they perform relatively simple experiments with materials such as blocks, springs, force tables, etc. In biology, students move on to more difficult lab experiments which use chemicals and more complex techniques. By the time students reach chemistry they must be able to follow specific directions, and to collect accurate quantitative and qualitative data. Once

again, it is easy to see the increasing skill level which students achieve as they move through their science courses. Honors students have even more opportunity to exhibit these skills when they perform the actual experiments involved in their yearly projects.

All students, regardless of the subject they are studying or the level at which they learn, should be able to research a topic in order to answer a problem or understand a concept. Not only is this useful in increasing the amount of knowledge a student gains from a course, but it is also a skill which all adults should have in case they need to make a difficult decision. Life sciences are a strong example of this as there are many health-driven reasons which lead most adults to do some degree of research at one point or another. Students in each track are expected to do research projects, whether it is Honors students working independently at home, or AE students using class time to do research in the media center with help from the teacher.

Another "strand" which one can trace through the AE and AF tracks but which could never be considered a component of science education is MCAS preparation. Because students must pass the MCAS to earn their high school diploma, faculty members have had to take steps to ensure that students are prepared for the test. Traditionally students receive the most preparation in English and math classes since these are the two disciplines which students must pass but in recent years science MCAS tests have been developed. Teachers in other disciplines were encouraged to give writing assignments and incorporate mathematics into their coursework. Because students are now tested in biology, there are specific efforts by teachers to make sure that students have covered all of the prescribed topics in biology by test time (which falls before the end of the school year), in addition to trying to bolster verbal and math skills in their own

classes. In fact, some of the course descriptions directly mention MCAS preparation in the list of covered topics.

Because one can never anticipate the needs or dynamic of a specific class until some time has been spent teaching them, a solid understanding how a course fits into the "big picture" of their education and the expectations for the track which they have been placed in based on past performance is extremely important in setting goals and designing an overall plan which caters to the students in the class and their educational goals. In addition to a solid grasp of the sequence of studies in the WRHS science department and the tracking system, it is important to keep the grand scope of the class in mind. It is easy to become too focused on the details of proper assessment, appropriate topics, challenging tasks, etc. and so forget the general goal of the class. As a student teacher I took on three classes; two sophomore Honors Biology classes and one AE Biology course. The true purpose of the AE Biology class was to provide a step in students' development of the science skills which are learned throughout the science sequence, and enough knowledge to prepare them for basic college science courses. The Honors class was meant to provide students with much stronger science skills (owing partly to the additional independent work and the quick pace in class), and enough knowledge to prepare them for possibly majoring biology or any related science. When comparing the classes to the state frameworks, it is easy to see the difference in knowledge gained. While both assess all the general frameworks listed, the AE course does not delve as deeply into the molecular aspects of biology, the intricacies of heredity, and mostly skimmed over anatomy and physiology. The Honors students learned about these topics in much more detail, though they also did not spend much time at all on

anatomy and physiology (this could be due to fairly recent addition of a number of frameworks pertaining to the aspect of biology). By occasionally stepping back mentally and reassessing how teaching methods help students to reach these goals and how a course's specific place in the WRHS science system, teachers can be sure to stay on the correct path to preparing students for what lies ahead.

Chapter 3 – Teaching

During my practicum, I taught four units to two honors classes, and three units to an AE class. Not only did the two different levels require different teaching styles, but it seemed as though each different unit required different teaching tools and types of materials. This is because the field of biology encompasses many smaller disciplines and aspects. Some of these approaches which I explored with my students were chemical, molecular, cellular, macroscopic, organismal, algebraic, genetic, and ecological. While there were certain aspects of my teaching which remained the same throughout all units and lessons, the types of course materials reflected the unit at hand. This chapter will identify the lesson structure and teaching skills which I developed across my entire practicum, and then explore the course materials from an example unit from each level which I taught. The materials will be presented with an explanation of thinking that went into them.

Despite the wide range of topics which a high school general biology course covers, there should always be a flow between different units. To achieve this, the teacher must take careful stock of which facts and skills a student needs for each unit, and determine the most sensible order to teach them in. Thus, each new unit (usually beginning the day after a test on the previous unit) should include a recap of material from the past few weeks, putting special focus on that which will be used in the new unit. Not only does this help set the stage for the new topic they will be grasping, it also gives students a sense of confidence about the new topic though it may be completely unknown to them.

I chose to start my units with lectures. Though my different levels and even specific classes had different needs from me as an instructor during lecture, I still worked hard to maintain a certain structure in each lecture, and based my lecture style on a few key points. The first of these is a well-organized and clear structure. The structure of these notes was meant to help students practice good note-taking skills, be able to identify what I thought main or related points were, and make it easy for students to look back at old notes and automatically understand the flow and key points of the lecture. Several examples of lecture notes can be found in the Appendix. It should be noted that the structure and outline of these notes is consistent across all lectures, despite the range of topics and different levels. The difference in content level and detail between the honors and AE notes should also be noted.

While lectures are a very direct means of communicating information to students, some students may not benefit from these lessons as much as others. While students who are extremely auditory learners do well with spoken lessons, more visual or spatially minded students may not benefit as much from written notes. To enhance lectures for these students, I used diagrams, graphic organizers, flow charts, and drawn figures as often as possible. These methods were also helpful for students in my AE class who had poor reading and writing skills. For many students, these more visual parts of the notes were the portions which taught them the most.

One decision which teachers must make when lecturing is how much they should write up on the board. In my AE class, I gave complete notes on the board. This way, all of my students did not miss any important points in their notes. If I did not give clear notes on the board, some students would end up with notes which were not sufficient to

work and study from. This was owing to either a lack of motivation on the student's part to take thorough notes, or a slower learning rate which made it hard for them to keep up. In addition to giving them clear notes on the board, I also gave the AE students a list of all important terms and concepts at the beginning of each unit. The "Chapter 8: Mendelian Genetics" worksheet is one of these outlines. At the beginning of each class I reviewed any new words they had learned the day before, and told them which of the key terms would be coming up in the current day's lecture or lesson. Whenever I was about to introduce one of these words, I would tell them to get this paper out and fill the answer in as well as copying the definition into their notes. Whenever I mentioned a word which we had already covered in class, I would ask for someone to remind the class of what it meant. If no one could remember, they could refer back to this sheet (by the end of the first unit they knew I would make them look at these worksheets for answers instead of giving them "easy answers"). These worksheets proved to be extremely useful to my AE students because it gave them a clear understanding of what was expected of them for the unit. When test time came around, this worksheet was an excellent study tool. It is also important to note that I made all students, including those who did not take good notes because of either a lack of motivation or a learning disability, fill this sheet in completely. This way I could be assured that while they may not have gotten everything out of my lecture, they at least knew these integral terms.

My honors students experienced a somewhat different style of lecture in that I did not give complete notes. Some notes were written up on the board, but this was often in an outline form with all key phrases laid out in proper organizational structure, and with concrete facts (dates, experimental results, etc) written out. It was usually left to the

students to provide explanations for conceptual aspects of biology. This is not to say that I did not explain these main points clearly in lecture, I simply challenged them to identify and reword the important points I was making. This proved to be a valuable learning tool for my students since they could not "zone out" and simply copy notes on the board. They were forced to pay attention and reflect upon the material I presented.

At this point, I feel it is important to identify one of the most important teaching skills which I developed during my practicum. This skill was the asking of questions. Though this seems like a simple concept, the ability to ask good questions which help students learn comes with a certain degree of practice. A good question will challenge students to "think outside the box", identify with the science in front of them, and lead them to come to conclusions for themselves without you telling them everything. Obviously, the more you can engage students and avoid droning on about a topic the better, but this is not the only reason for persistently asking questions. In addition to engaging students, one can also lead them to develop better investigative skills. Many students look at science as a set of facts and principles which they need to learn, but contrary to what they may thing, science is a process. The scientific method, which encompasses the process of identifying problems, hypothesizing, developing methods to test these expectations, and using data to analyze our world, should be present in all aspects of any science course. To incorporate this process of investigation, teachers should constantly be presenting problems and questions to students and encouraging them to provide their own answers and take on the issue. Hopefully students will respond to this approach and begin to ask well-developed and insightful questions. While the most direct goal of my classes was to provide students with knowledge about biology, I

also strove to help them to develop investigative skills which they could carry with them whenever they use science in their lives. In all lessons and course materials which I developed, I strove to make this theme an integral part of the lesson.

Before students can be expected to make insightful observations and queries, they must gain a certain command of the topic. While lectures are the most direct way for teachers to show students what they need to know, there is often a need for more detailed explanations which the teacher does not have class time to cover. This is where the textbook and other outside reading comes in. Not only does it allow students to go over the information at their own rate, it also provides them with extra information. There are several ways which teachers can incorporate the text into their class. In my honors class, I mostly treated the text book as an outside learning tool. While it was expected that they read the entire chapter for each unit, we did not spend much time referring directly to the book. Usually I would tell them which section of the chapter the notes for the day related to, and I might use a diagram in the book to illustrate the topics. In the AE class, we spent much more class time using the book. I always told them which part of the chapter the notes were based on (the section number went up on the board), and on several occasions class work required them to use the book. These exercises either involved taking their own notes on the chapter, answering the questions at the end of the sections, or using the text to help them work on other assignments. Often times, they were assigned specific reading along with written answers to the questions for homework. These assignments were meant to ensure that students were completing the outside reading, and spending time to reflect by answering the questions. Because my AE students were not usually required to read the entire chapter, and because sometimes

there were students who needed more explanation for a concept, they often received worksheets which included reading sections. For example, after a lecture about genetics, they might read a section of the text and answer questions with a partner, then take home a worksheet with additional literature about genetics and answer the questions at the end of it. This reading helped them reinforce the points which I was making in class, but gave them a varying teaching style so the information would not seem too stagnant.

While giving students direct instruction about a concept through lecture and assigned reading is extremely important, a good teacher understands the importance of literally showing the subject to students. Science teachers in particular should remember that the discipline is physical; students should get to see, touch, and manipulate materials as often as possible. Not only does it give students valuable insight, it is also a wonderful learning tool for more tactile learners. Demonstrations are not only useful, they are enjoyable. Science teachers will acknowledge that one of the best parts of teaching is intriguing students with in-class demonstrations. When my students walked into a classroom full of skeletons and skulls one day during our unit on the evidence of evolution, they were much more enthusiastic about the lesson than when they knew they were walking into a day of notes. I had laid out skeletons from every vertebrae class, a series of primate skulls, a human skeleton, and several other artifacts. I guided my students through the process of investigating the bones and comparing the anatomy of different animals. We practiced putting the different organisms into some kind of order, and decided how to categorize them. We also found homologous and vestigial structures. I truly believe that classroom learning should be fun, and that if a teacher can get a student to say “wow” every class, then they are truly opening their eyes to the world of

science. The bones demonstration certainly intrigued my students. On a different day during this unit my honors students walked in to a pile of "rocks" which turned out to be various fossils. Before I had even begun to talk, they were gathered around a lab bench talking about the fossils and passing them around. We moved through a guided inspection of the fossils, and my students gained firsthand knowledge of the characteristics of different types of fossils. It was not surprising that my students did well on the fossil portion of any assessment.

Demonstrations with the AE class were somewhat different than those with the honors classes. While the honors students could stay on-task with a loosely structured lesson, the AE students need more structure to keep them focused. During AE demos I usually had students stay in their seats and pass objects around, or watch one volunteer perform the demo. For example, when explaining the life cycle of a cell between divisions I had one student come to the front of the class. I handed him a piece of paper which represented a cell and told him to "make it divide." He looked at the paper for a moment, and ripped it in half. I then explained that these were daughter cells, and asked him what they needed to do before dividing. Zack answered that they should make another copy of their DNA. I told him to assume this was happening and to continue to make them divide. After a minute Zach had a pile of paper scraps too small to rip. The class now realized that an important part of the cell cycle is the part where cells have time to grow back to normal size before divisions. While this demonstration was very simple, it still made a strong impression on my students, and led them to discover a cell process which I had not yet told them about.

Once students have the knowledge they need about a topic, the time comes for them to apply this knowledge and practice new skills. This is where worksheets and other individual practice opportunities become important. I feel that worksheets are a wonderful way for students to practice skills and strengthen their command of concepts. While worksheets usually follow a specific format (title, instructions, questions which can be quickly and simply answered), there is much room for teachers to be creative with their means of asking questions. When a teacher gives students worksheets with a range of different types of questions, students must communicate and apply their knowledge in new ways. Several examples of worksheets which I developed for my classes can be found in the Appendix.

The "Operons" worksheet which I made for my honors students during the unit on protein synthesis was a useful learning tool (see Appendix A, p. 95). The operon hypothesis was the final topic covered in a unit which focuses completely on molecular processes. The synthesis of proteins is an exacting process which can be very difficult for students to visualize, especially because there is no way to physically show them how the process works. To understand gene regulation through operator genes, my students needed to be able to apply several other concepts they had learned. To make the topic more difficult, their book provided only a brief mention of operator genes and no real explanation of their mechanics, since operons are not typically a subject for first-year biology students. To help students, I developed a worksheet which provides an explanation of operons from a different textbook. The rest of the worksheet requires students to analyze a symbolic drawing of the gene sequence and enzymes involved in operons. The first portion of the worksheet requires students to label the parts of the

diagram which represent different parts of the gene sequence. This requires some insight and creative thinking since they had never seen this way of drawing the operon mechanism before. After they label and explain the sequence, the second portion of the worksheet requires them to identify the three main steps of the mechanism, which are drawn on a second diagram. Overall, the worksheet gave students additional information and immediately required them to directly apply and conceptualize the topic. Once the worksheet was filled in it looked more like notes on operons, and because a useful study tool for my students.

While most of the worksheets which I gave to my honors students were more conceptual or provided practice for the many skills they learned (such as practicing the algebraic approach we took with genetics), the worksheets which the AE students used were more straightforward and required less insight to complete. Most of the questions related to key terms or processes instead of more conceptual or in-depth questions. For example, AE students would be asked to label or redraw a diagram which could be found in their book or fills blanks in with key words from the notes. Most of the questions on AE worksheets were in the same format which students might see on a quiz or test. All of the worksheets which I developed for these students reflect their need for structure in class. Two examples of these would be the "Words to Know" worksheet which they filled in with definitions taken from the notes I gave them (see Appendix B2, p. 150; and Appendix C2, p. 206). as well as the end-of-chapter "Mitosis Review" worksheet (see Appendix D, p. 236). The mitosis worksheet followed a basic fill-in-the-blank format, but what slightly more conceptual since it did not provide complete sentences. It also required students to fill in a diagram with only the notes on the left to guide them.

Because this was such a conceptual worksheet by AE standards, we filled it in as a class review the day before the test. Had I given this worksheet to honors students, they would only have needed about ten to fifteen minutes to complete it individually.

Oftentimes when one selects a worksheet or any other activity for students to complete, a decision must be made as to when the appropriate time for students to complete it is. Mainly, should class time be spent on this activity, or should students complete it for homework? There are a few factors to consider when making this decision. First, is this something that students can complete on their own? If such is the case, then class time should probably be spent on a more challenging task which students will need guidance to complete. If it is too difficult to finish at home, then it can be completed as a class, in groups in class, or individually with the teacher answering any questions. I personally dislike having students sit quietly and completing worksheets individually. I feel that having students work together makes it more fun for them, allows them to learn from each other and pool their knowledge, and makes it easier for the teacher to help several students at once. In my AE class we usually started worksheets which pertained to the day's lecture as a class so that they could see my expectations, and then students finished class period by working together. They usually had ample time to finish the worksheet, but if they didn't finish it was homework. Because one of the parameters of the AE track is that homework is not assigned every night, my students usually only had homework a couple nights a week. Most homework assignments were either worksheets or the review questions found in the book. Worksheets were usually meant to help them develop skills, such as performing genetic crosses, or to help them reflect on what they had read in their text book. To ensure that

students completed this work I would start class the next day with a homework check, where I would give two points for completing the assignment. All homework questions were reviewed in the AE class, and students were expected to correct their mistakes and study from these activities.

Homework was treated differently in my honors class. The worksheets which they took home to finish were usually much more conceptual, more like "mini labs" when compared to AE worksheets. While AE assignments usually required students to relate whatever they had learned in class that day, honors assignments required students to apply concepts they had learned to different situations. For example, the "Evidence of Evolution" worksheet (see Appendix E, p. 271-273) was a homework assignment which my honors classes completed. This was the night after our in-class demonstration using various skeletons. The worksheet asks the students to consider a collection of mammal arms (in class we had used skeletons from each type of vertebrates), identify corresponding bones in each arm, and explain the different arrangement and relative sizes of the bones. Additionally, the worksheet asks for students to identify analogous structures which we had discussed during lecture but had not observed with the skeletons. This worksheet started by looking more closely at the type of comparative anatomy we had discussed in class, and then asking them to look at a broader type of comparative anatomy which we had discussed but never observed in class. This assignment was then graded based on the quality of the answers, not completion. Honors students are expected to handle a fair amount of homework, the challenge is to show a degree of insightfulness and knowledge when complete these assignments. While I would always ask if anyone had had difficulty with specific questions and review any especially

challenging questions, I never went over the homework with the students. This was partly because honors students should have made note of the corrections I made when grading, and because the class must move at an accelerated rate. To succeed in honors classes my students had to learn to identify concepts they had difficulty and take it upon themselves to seek extra help, which I always gave very willingly.

Sometimes homework required more than the applications of new terms of a new concept to answer a few questions. Occasionally, I gave larger assignments which took my students a few nights to complete. The most interesting assignment for my honors students and I was most likely a research assignment they did on various genetic diseases during the chromosomal genetics unit. I asked students to write about "the most intriguing genetic disorder you can find." The "Genetic Disorders Research Assignment" sheet which I handed out (see Appendix C1, p. 194) gave an explanation of what type of information their reports should include. Included in the list were items that would reflect their ability to find accurate sources of information, as well as inferences made based on what they learned about the disease and knowledge about the mechanics of genetics learned in class. Overall, this assignment showed the ability to manage a larger amount of work, to research a topic, to communicate scientific information in a well-written paper, and to connect knowledge of biological processes to specific cases. It also gave them insight into the implications of the life sciences on peoples' lives.

The final component of my lessons was that which gave my students the most practical experience with the material I taught them. These lessons were through laboratory experience. While it is true that many scientific principles and theories are very theoretical, science is also the most tangible and tactile of any main subjects.

Science teachers have the opportunity of using this aspect to their advantage. While demonstrations are a wonderful way to show students the science one is explaining, there is no lesson which can compare with actually having students perform the lab techniques and discovering various phenomena just as researchers do. There is an old Chinese proverb which says "Tell me and I'll forget; show me and I may remember; involve me and I'll understand." To some degree, this describes the learning process in a high school science classroom. While students will learn from lectures, physical demonstrations will provide more memorable lessons, and allowing students to physically manipulate science themselves will provide lasting understanding. On several occasions when my students were struggling to recall what they had learned in a previous unit, I often found that the best way to jog their memories was to refer back to a lab we had done. For students who are tactile learners especially, lab exercises could be the most useful and enjoyable lessons of a unit.

In the WRHS science department, there is a definite focus on the investigative side of science which stresses the use of labs for instruction. This stems from the principle that science is not just facts, it includes a skill set. The greatest skill students can learn from a science class is the ability to identify a problem, and use their knowledge to conduct an investigation of the issue at hand. Laboratory lessons develop their ability to investigate by teaching them about the scientific method and teaching practical lab skills.

When planning a lesson which involves a lab exercise, there are a few notes to keep in mind. First, all directions must be clear and straightforward. During class, when students asked me questions about how to do the lab I would refuse to answer anything

that I knew was written in the directions, or which I thought they could figure out for themselves. If I had not been confident that the directions were clear and concise, I would not have been as confident in instructing them as such. It is also important to dedicate a portion of the lab to reflection. Before students began the lab we would discuss the concepts involved in the lab and hypothesize about the outcome as a class. During the lab, I would often have everyone stop working so that students could offer observations and discuss and problems as a class. We always discussed the lab afterwards, and they always had written questions which they needed to answer. During labs my students were encouraged to do extra investigations, and some students even altered the procedure somewhat with my permission. Students always worked in groups during labs because of resources and so that they could learn from each other's perspective and observations. They did have to complete their own work, and handed answers to lab questions in individually.

The most successful lab which I developed for my honors students was one in which they modeled natural selection on a population (see Appendix E, p. 253-259). Each student was a fictional animal which we decided on as a class, and had a knife which they used to collect pasta to "eat". There were several rules and parameters which helped to model a population and genetics. Over time we introduced "mutations" and decided on new variables to test as a class. Later, the class split into smaller groups and performed different types of models. The entire lesson took place on a field next to the school, and students were encouraged to use the space and be as innovative as they wished with the experiment. It is difficult to design labs to test the process of evolution, which is a slow process which occurs on large populations, but this lab taught the lesson

very well. This was the only lab which they had to write a formal report for, and their answers to the discussion questions were very insightful. The report also gave them a practical lesson on formatting a lab report and writing a technical paper. Adding to the educational benefit of this class, my students told me several times that it was their favorite biology lesson of the year and that it felt more like a game than a class.

An interesting lab which I designed for my AE students also modeled a phenomenon which is difficult to test in a high school laboratory. This lab used pipe-cleaners to model meiosis (see Appendix D, p. 232-235). Because the process and need for meiosis is more conceptual than those of mitosis, my students needed a very straightforward way to experience the process. Using pipe-cleaners to model chromosomes, they had an opportunity to manipulate the structures which they were learning about, and experiment with different parameters. I had to do a great deal of demonstrating with this lab, but it did prove to be a useful lesson which I referred back to on many occasions to review meiosis. Because the lab required them to sketch the model at each stage of the investigation, those who did a thorough job on the lab had excellent study materials to look back on.

Overall, the process of developing materials for seven units' worth of lesson taught me a great deal about teaching. During my four months of student teaching, I learned to develop materials which challenged my students to develop different learning skills, instructed them in the study of biology, provided structure to the class, and catered to the unit at hand. Most importantly, I developed materials and lessons which intrigued my students and spurred them to seek answers about biology.

Chapter 4 – My Students

Every teacher has his or her own teaching style, and a student teaching practicum is the first opportunity to discover what that style is. While competence and the ability to design effective learning tools for students are extremely important, a good teacher must have the flexibility and insight to teach to the specific students in the class. This requires the ability to determine what their strengths, interests, and needs are. Teachers must allow their own personality, as well as those of their students, to shine through every lesson.

The rules and expectations of a classroom must be carefully constructed based on the teacher's character, the goals of the class, and the abilities and personalities of the students. Aspects of the class such as the lesson layout, homework and attendance policies, and rules of the classroom should be established by the teacher by the time she teaches her first lesson to a class. At this point she attempts to engage the students and draw out their individual personality. As she gets to know the students and understand their abilities, she can begin to cater lessons and teaching style to their needs and interests. This is a basic process which occurs in every class, and I had the opportunity to work with three separate classes of students. As I taught, I felt myself going through the initial phase of setting my own rules and the tone of the class, the stage of drawing students out, and then found myself beginning to design classes and materials which targeted the class' abilities.

I feel that the more straightforward teachers are about their expectations of themselves and students, the better. From the onset, my students were made to understand that if they did the work and reading, they would have the tools to do well in the class. My students also knew and were constantly reminded that they always had the

option of staying after school for extra-help sessions with me. When in class, I expected my students to be responsible for themselves. While lecturing I always required that notebooks and "Words to Know" sheets were on their desks, but I did not stand over them to make them copy notes. The two biggest rules were that a) students could not distract others from learning, and b) they could not be doing anything besides the task at hand in class. In other words, they did not have to take the notes I put on the board, but talking with neighbors or doing work from other classes was not permitted. Another major rule was that cheating was not allowed. If anyone was caught cheating on any task, they received a zero. Any time someone's behavior was unacceptable, they received a warning. If the behavior was repeated, disciplinary action might be taken. Any consequences which I inflicted were meant to be educational, or to make the atmosphere of the class more conducive to learning. Overall I attempted to make the classroom as positive a place a possible, and to nurture an excitement and enthusiasm for science. I often joked around with my students, and allowed them to see my sense of humor. "Miss G's corny bio jokes" became a constant point for my students to tease me about, but often were the best way to remind them of a discussion topic days later. I also was willing to get somewhat side-tracked during lecture if a student posed an insightful or intriguing question, even if slightly unrelated, about a concept we were discussing. I truly believe that students found me approachable, and knew that I was always willing to help them learn.

This general teaching style was established right from the beginning, but the specific ways to implement my ideals and reach our learning goals were learned as I went along. Most teachers would agree with me when I say that beginning teachers learn as

much from students as their students learn from them. Many of my teaching techniques were learned through a trial-and-error process with my students. While I maintained a solid structure for the lesson plans, I constantly tried using new, creative methods for teaching within this context. Their level of engagement, assessment results, and apparent enthusiasm about these lessons served as my gauge for the success of my lessons. Some of the lessons which learned were the proper way to manage a rambunctious class during a lab session, how to spend forty minutes lecture and keep students interested, how to make quiz and test-taking a less stressful experience, and how to design notes which all of my students could benefit from.

As I mentioned, a true trial-and-error process was necessary to learn what did and did not work for me and my students. Often, it was the "little things" that made a big difference for my students. There are several ways that I took the basic components of a science class (lecture, homework, assessment, demonstrations, etc) and spiced them up according to my own teaching style. For example, I found some fun fact for each lecture which I knew would surprise my students. I would present the problem or general concept, ask them a question about this fact, and then give them an actual answer which was usually surprising and unexpected to my students. As I mentioned, I also included as many silly puns and tricks to remember things as I possibly could. While my students groaned about my jokes and teased me about my tricks, they used and remembered them. This also demonstrated my own enthusiasm about biology, and about their learning process. While these tidbits made up only a small part of the lectures, they helped create an atmosphere of enthusiasm about science and helped to engage my students.

The lessons which contrast the most with teacher-centered lectures are the more student-centered lab lessons. While labs have the potential to be extremely interactive lessons, a teacher must sometimes draw upon her skills to motivate students to work when a teacher is not standing right over them. A technique which I used to engage groups of students during lab lessons was to have students share data. The "Genetics of Maize" lab (see Appendix B1, p.129-131) with my honors students and the "Smiley Genetics" lab (see Appendix B2, p. 161-164) with my AE students both required students to use data from the entire class in their analysis. This made all students accountable not only to themselves, but to other students in the class to get their work done. Another way to engage students was to allow them to redesign lab experiments to some degree. The "Natural Selection" lab with my honors students (see Appendix E, p. 253-259), in which they learned about natural selection on hunting adaptations by modeling a population themselves, is a fine example of this. Each group ran a few trials of the experiment, and was free to add new variables or controls to the experiment so long as they explained their results in their lab report. This reinforced the investigative spirit of the class, and allowed them to have more ownership and enjoyment during the class. During an AE lab in which students used yarn and pipe-cleaners to model mitosis, my students were also allowed to experiment and explore the models in front of them to visually answer their own questions. Personally, I feel that a lab in which students have the insight and motivation to redesign a lab somewhat to answer their questions much more successful than one in which students follow all directions perfectly and are not as interested or connected to their findings. Just as I had to monitor my own discovery process as a student teacher, my students were learning to monitor their own investigative

process in these labs. These lessons also engage students much more, which is one of the major responsibilities of a teacher.

There were many other methods which I employed to increase student involvement in my classes. Review games as extra incentives, friendly competition during the games, multi-media classes with videos, pictures, newspaper articles, and resource books, lessons outside, and class debates on bioethics were some lessons which I found truly engaged my students. Not only did the many aspects of the concepts which they learned through multiple approaches spark their interest, but the unexpectedness of these lessons kept them curious and excited to come to class. As I got to know my students better, I was able to tailor lessons to each class' personality even more. This made lessons more enjoyable for myself and my students.

Not only did the many ways of presenting material keep my students on their toes, it also ensured that there was material geared towards all of the learning types present in my classes. While psychologists argue about how intelligences should be categorized, they do agree for the most part that there are distinct types of intelligence and learning styles. In my classes, I worked with students who I would consider visual, verbal, group, individual, and kinetic learners. I had to keep these different learning styles in mind while planning lessons and answering questions, and learned a great deal about what does and does not work for these different learning types.

My students who were what I would call verbal learners were probably the most comfortable at the onset of any new unit. This is because most units began with a lecture. Because lectures were completely based on me essentially talking to students and engaging in dialogue with them, students who learned through spoken communication

were very comfortable during these lectures. The points which were difficult for my verbal learners were activities which involved a great deal of math, or extremely mechanical concepts such as the movement of molecules in synthesizing proteins or the movement of chromosomes during meiosis. For these students, I often broke processes into steps which could be explained. For example, when teaching them how to perform the algebraic foil and use probability in solving genetics problems, I broke the process into steps which explained the mathematical approach: 1) Identify and explain the alleles, 2) Explain and write in notation the parents' genotypes, 3) Determine the sex cells, 4) Foil the sex cells to find all genetic combinations, 5) Write the genotypes and phenotypes in ratios with full words (see Appendix B1, p. 108). Note that several steps encourage students to "explain" the step. Whenever my more verbal learners had difficulty solving genetic problems, I would suggest that they break the problem into steps, and explain the steps to themselves as they went along. I was not surprised to see the list of steps penciled in at the tops of several quizzes and tests later in the unit. If students had been told to simply find the parents' sex cell combinations and foil them to find the genotypic and phenotypic ratios, most would have struggled for some time simply deciding where to begin solving the problem.

Sometimes, simply having these verbal students talk their way through a problem helped them a great deal. During our second genetics unit, two of my honors students stayed after because they could not solve many of the homework problems. After a quick review of the overall material, I told them that it seemed to me like they knew the material and should be able to solve the problems just fine. "But Miss G, every time I try I start getting the steps confused." In response, I wrote a problem on the board and told

them that they had to solve the problem out loud. They were told that they could use the board to keep track of the math and steps, but that their work should be done out loud. As they talked their way through the steps, writing whichever part of the problem they had solved along they way, they slowly talked the problem out together. By the end of an hour, they had literally explained the process to themselves and each other with very little help from me, and could now sit silently and accurately solving the problems individually. It was clear that they knew enough about the material to solve the problems, they just needed to verbalize their thoughts in order to apply the concepts to concrete problems. Talking to one self is actually considered an important part of cognition when learning, and it was even given the formal name of "private speech" by the famous education psychologist Vygotsky[5]. While it is important for everyone to be able to use verbal communication and self-regulatory internal language when learning new concepts, it is especially important target this need in verbal learners.

I encountered a second learning style with the verbal learners in my classes. Unlike students who liked to talk about and listen to lectures on a topic, these students had a difficult time conceptualizing ideas which were not pictured in front of them. It was usually very easy to incorporate visual learning tools into our class. I had students draw diagrams into their notes, make sketches of slides under the microscope, and showed pictures and videos in which they could observe the phenomena. For topics which were too conceptual to actually draw, we used flowcharts and other graphic organizers to help them visualize difficult concepts. Just as the verbal learners in my class were encouraged to "talk problems out," I also tried to help the visual learners recognize their tendencies and work with them. Because I rarely wrote everything I

[5] Santrock, John W, *Educational Psychology* (New York: McGraw-Hill, 2008), p. 50.

lectured about on the board for the honors class, I encouraged students to organize their notes in a way which would be easiest for them to understand later. My AE students were even encouraged to "add on" to the notes I gave them. When walking around the room it was easy to recognize the visual and verbal learners. While the verbal learners tended to write extra explanations, the visual learners often had their information organized into charts or had sketched pictures from overheads into their notes. If the AEs had open books in front of them, they were also encouraged to reference helpful diagrams in their notes. I also encouraged them to draw arrows between connected ideas, or to color-code their notes. Sometimes these students were even encouraged to draw their problems out for me. I had one very shy student who had a difficult time phrasing his questions, which were often very insightful and helpful to other students. One day when he was struggling to explain a question about chromosome movement during mitosis versus meiosis, I asked him to draw the question out for me. When he showed me the question a few minutes later, I had a much easier time understanding how to communicate the answer to him and the rest of the class. His question was so helpful to his fellow students that I had him draw his version of the diagram on the board so that everyone could put it into their notes. From then on when this student asked me a question, he often asked me to come to his desk so that he could point out the parts of the notes that he did not understand.

Because I am a very visual and verbal learner, I had a relatively easy time learning how to teach to these types of intelligences. One area I did struggle in was targeting the more mechanical and spatial learners in my class. These were students who had difficulty in understanding my spoken lectures. While visual cues helped them

somewhat, my initial style of lecturing was lacking in the type of instruction which helped them most. These students needed more hands-on lessons, demonstrations, and lessons where they did not have to remain in the same seat the entire time. One of my honors students was an intelligent boy, but he often had some degree of difficulty in gleaning much new knowledge from my lecture-based lessons. One unit which he struggled with especially was the Evidence of Evolution unit. Because evolution is a fairly long process, and was discovered through observation of the natural world than lab experiments which could be shown or demonstrated, it was often hard for this student to grasp the concepts. Finally, he began to catch on to the concepts we discussed when we took our lesson outside to create a physical model of natural selection. My students each played an animal with an eating utensil which they used to gather macaroni. Over time, those who had eating utensils which were more efficient for packing macaroni "reproduced" more, and the class "evolved." Suddenly, this student began to understand the concept of natural selection and evolution quite clearly. Because several of the students in the class had similar problems during the Evidence of Evolution unit, we had as many in-class demonstrations and hands-on materials as I could cram into the unit. A huge number of skeletons, fossils, and other artifacts were brought in so that students could hold and compare different types of organisms and the process scientists use to learn about them. Group work, or even the opportunity to sit wherever they wished in the classroom also seemed to help these students to focus on the lesson.

Aside from the way which students process information, there are other aspects of learning styles which teachers must consider. One of these aspects is the social contexts which students benefit from in a classroom setting. While some students are extremely

good at self-regulating and processing information individually, other students benefit greatly from a group atmosphere. While these two tendencies could be noticed in students from all of my classes, these needs were more marked in my AE class. Because my honors students were motivated, flexible, and driven students, they tended to be more focused than my AE students and could take new ways of learning on more easily. AE students faced more of a challenge in understanding many concepts, and so they were often not as willing to take on new challenges. This led to very distinct "comfort zones" in terms of the teaching methods which helped them the most. Group learners were easy to spot. Even when these students were sitting quietly at their desk with only their work in front of them, they often became very distracted or lacked the enthusiasm and motivation to complete their work. For some of these students, placement in a group of other students who all shared the same goal was beneficial. They enjoyed the opportunity for interaction with their peers instead of sitting by themselves, and did quite well when they focused their attention on the topic as a group. There was a group of boys in the AE class who each had a very difficult time focusing when doing individual work. One tended to doodle on the side of the worksheet, another constantly asked other students how they were answering problems, and two would actually lay their heads down and try to sleep if left to their own devices. Putting them into a group together woke them up both literally and figuratively. Thought I had to check on them every so often to keep them on task, they were generally productive as a group.

Sometimes, it is very easy to mistake an individual learner for a group learner. We often think of group learners as social, talkative people. This is not always the case. I had three students who were extremely talkative, personable, and social who rarely got

anything accomplished when working in groups. This is because they were easily sidetracked by conversation, and had difficulty keeping their attention directed towards the work in front of them. While these three students often resisted, sometimes very strongly, working individually, they usually got much more done without the distraction of group members. Aiming lessons towards these individual learners was sometimes difficult since I usually tried to maximize time spent on in-class teacher to student communication, and also because I did not always have the resources or space to have students work on tasks such as labs individually. However, my philosophy of student-teacher communication during group work countered the negative effect of group work for these students, since I could check on the groups frequently to make sure that they were staying on-task.

Taking specific learning needs a step further, I actually had several students who had Individualized Education Plans (IEPs). The IDEA mandates that all children with disabilities must have an IEP created for them by a team which includes parents, educators, people knowledgeable with the school's resources, and specialists who understand the child's needs. A child's IEP sets a program which is designed to improve teaching and learning results by meeting a child's specific educational needs[6]. In my AE class there were students whose IEPs mandated that I make several accommodations. When teaching, I needed to use graphic organizers (such as flow charts, Venn diagrams, etc.) on worksheets and notes. The "Mitosis and Meiosis" worksheet contains a flowchart which students had to illustrate and label (see Appendix D, p. 236). I rarely had to make any extra effort to meet this provision of the IEPs, since I tend to incorporate

[6] *My Child's Special Needs: A Guide to the Individualized Education Program*, http://www.ed.gov/parents/needs/speced/iepguide/index.html#closer.

graphic organizers into most of my lessons anyways. When giving tests or quizzes, I had to provide word banks, which can bee seen on any of the AE assessments which I wrote (see Appendixes B2, C2, and D), and let certain students have extended examination time. I ended up giving all of my students the same tests, and so everyone in the class used word banks on their tests. This did not make the tests easier for the whole class, since it was possible to design questions which were challenging for the AE students, even with word banks. I usually gave them more words in the word bank than they actually needed.

I had a few students who did not have IEPs, but still had reading difficulties. While biology is not as reading-intensive as disciplines such as English and history, my students still needed to be able to learn from textbooks and supplementary reading materials. We sometimes read materials as a class, where different students were called upon to read different passages out loud. I soon became aware of the fact that some students were very slow readers and were sometimes uncomfortable reading in front of their classmates. Because extra reading help was outside of the scope of the class I did not require all of my students to help read the materials and usually asked for volunteers instead, and always reviewed what we had just heard with the class immediately after we finished reading.

One student's reading and writing problems were not due to slow learning, but actually were the result of a language barrier. This student spoke English as a second language (ESL), and though he was very comfortable speaking, his reading and writing skills were impaired by his lack of experience with the language. While I did not have the time in class to focus much on his language skills, I was able to address his

difficulties by giving him some one-on-one time to help him organize his thoughts when completing writing activities.

Clearly, I had considered the different learning styles and needs of all my students while determining my approach for each unit and creating lesson plans. To complicate the lesson-planning process even more, behavioral issues were another point of classroom management which I had to recognize on an individual basis. When considering the strongest behavioral problems which I encountered in my classes, most of the instances fall into four patterns of behavior. There were the students with low maturity levels, those who sought constant attention, those with negative attitudes, and those who had diagnosed conditions which made them act up. Each of these issues presented themselves through different types of behavior, and had to be dealt with by myself in different manners.

While there are certainly strong patterns of development which children and adolescents exhibit, there are always individuals who develop at a different rate than their peers. I had two students who, simply put, were immature for their age. All of my students were sophomores who were either fifteen or sixteen years old, but as my mentor put it when describing one of these students they "act more like middle-schoolers." These two students spoke out of turn, made jokes about other students, tried to distract me, and failed to take their lessons seriously. One of these students was an honors student, and one was an AE student. In both contexts, other students were annoyed and the lesson was disrupted. While I dislike criticizing students and tried to reserve the act of making a real spectacle for moments when the entire class was misbehaving and I needed to make a strong point, I did react to these students in front of their classes. First,

the students were told their behavior was inappropriate. If this behavior continued, they were taken aside during or after class and I spoke with them privately about the type of behavior I expected and the type of disciplinary reaction I would have if the behavior continued. It is important to note that these students were not acting up out of malice or because they did not care about their studies, they simply were not as mature as most of the other students were. They had trouble taking the subject seriously, cracked silly jokes, and needed extra guidance to keep them on task, just as a student a couple years younger would need if thrown into a sophomore biology class. By explaining the problem to these students, they took their role a little more seriously. I ended up moving both students to the front of the classroom where I could keep my eye on them and nip any misbehavior in the bud. These were not what I would call "problem students" in that they usually did not recognize or revel in the problem they created, as several other students did.

Unfortunately, several of my students did fall into the category of "problem students" on a few occasions. Two of them were a classic case of what we call "attention seekers." These students desired the attention of myself and the class so much that they often interrupted me, disrupted their classmates' work, and made what they felt were shocking statements so that others would focus on them instead of the lesson. They both understood and disregarded the detrimental effect they had on the class. Even when I asked them to behave and gave them warnings, they continued with this behavior. When told they had to move their seats to the front of the room, they both argued with me. One student actually refused to switch seats, until she was told to decide between switching and coming back to sit in her seat during detention. Even when one student's mother was

contacted regarding the problem, her behavior in class continued. Both of these girls fed off of the reactions they received from their students, and my continual attention, even if it was to reprimand them. Eventually I realized that it was better to work with these students than to focus on them stopping their behavior. One day while one of my honors classes was watching a video, I pulled a chair up directly next to one of these students. I had done this so that I could stop her whenever she began talking to and distracting her classmates but found that instead she focused her attention on me, asking questions about the video and discussing the science she was learning about. During our discussion after the video she was the most engaged student overall, working hard to show what she had learned. The other attention-seeking girl was in my AE class, and I realized over time that her behavior stemmed mostly from the fact that she was bored. While she was an intelligent girl, biology did not come naturally to her. When I began to give her extra help, encouraging her when she worked hard and congratulating her on her successes, she began to work less to get the classes attention through inappropriate outbursts and worked more to contribute to class discussions. She even became eager to show me what she had learned and was somewhat competitive with other students – both traits which I often saw in my honors students but rarely witnessed in my AE class. While these students did not lose their need for attention in the short time I spent teaching them, I did learn how to manage the class and work with them so that the effort they put into negative behavior was redirected towards their studies.

While the problematic behavior of attention-seeking students and those with maturity problems can usually be overcome by working with students to redirect the focus of their energies, there are some behavioral issues which are not as easy to deal

with as a teacher. Students who do not handle authority, are rude and inconsiderate, or are unmotivated workers can be a greater challenge for teachers. This is because students who misbehave maliciously tend to gain satisfaction when the teacher makes it clear that she is displeased with their behavior, and the consequence of losing points or doing poorly in the class matters little to students who do not care about the class in the first place. I had several students with attitude problems in my AE class. I had students who swore, tried to sleep in class, blatantly refused to work, made a habit of talking over me, enjoyed playing games instead of paying attention, etc. When deciding how to react to these students I had two factors to consider. First, there was the question of how to motivate these students. It is easy for teachers to compare low achievers with motivated students and begin to classify students with poor performance as "losers." In these cases, I found that it was best to view these students as a challenge, and work with them. I gave them a great deal of moral and academic support, even when they did not ask for it or did not seem to want it. When they did poorly on an assessment I discussed with them what they could have done to improve their performance, and when they did a good job I pointed it out to them and asked them what had changed. In many cases lack of performance comes from a fear of failure or conviction that they can't perform. As one student who made a point of not trying in class told me, "I'm not book smart, so why should I try?" The fact that this student did struggle a great deal learning in a classroom setting made it difficult to convince him that he could pass the class with a C grade (he had a made it difficult to convince him that he could pass the class with a C grade (he had a 45 average at the time) if he applied himself. First I promised him that if he began to apply himself in class he would get better grades since some assignments were graded

purely on completion. When he was encouraged for getting full credit on these assignments, it was clear that he pleased to hear a new type of feedback from a teacher. His mother had been contacted about his danger of failing the class by this point, and so she made him begin to study at home. His next quiz contained the best work I had seen this student do, and he actually earned one of the better grades in the class. When I announced this to the class, he was clearly pleased with the public encouragement and recognition by his fellow students. While it is impossible to force students to work until they take the first steps towards applying themselves, a teacher can increase their motivation a great deal by providing them with encouragement, extra help and attention, and positive feedback for a job well done. It was also extremely helpful to have the parental support for this student. I had a second student who actually dropped out of school a few weeks after I began teaching. While this student's parents had been contacted many times about his danger of flunking out, they did little to motivate their son. While his teachers worked hard to get him working harder, the reinforcement of his lack of effort by his parents overrode the influence of his teachers. While this was an unfortunate case, I had several students whose achievement improved a great deal without me ever needing to contact their parents.

The second question I considered when reacting to students with attitude problems was "how do I show them the negative impact of their behavior?" Students who purposely try to disrupt class or insult and disobey teachers usually gain a sense of amusement or personal power by doing so. The first step to dealing with these problem students is to depersonalize the situation. I reminded myself that I had a job to do, and that I couldn't let my students get me emotionally upset. The second step was to show

the students that they were only bother the people around them, and hurting themselves. One of my AE students had a very marked attitude problem which disrupted our class a great deal. One day his behavior was so disruptive that I told him to take his work to a desk in the hallway and work by himself. When I went out to talk to him about the situation he asked me why I was always "picking on" him, and told me he thought I was mean. I replied, "Zach, I'm not punishing you because I don't like you, I'm punishing you because you're taking away from yourself and your classmates." When the student went to my mentor to complain about me and told him that I was mean, my mentor replied, "Do you think Miss Gikas really cares about what a kid who messes around during class thinks of her?" I believe that the combined effect of our two reactions made the student realize that when I disciplined him it was not out of malice – it was simply a reaction to his behavior. As he walked into my class the next day I reminded him that it was his decision as to whether or not he would get into trouble today, and that if he did it was out to the hallway again. That day he was not only better behaved, he actually had an uncharacteristic handle on the subject matter since he had spent the previous class with nothing to do but focus on his work in the hallway. For the first time, he received positive feedback from me instead of reprimands. Perhaps my student realized that I was not as "mean" as I seemed, and that I was very willing to encourage him. While this boy was never a model student in my class, his behavior and grades improved a great deal after those few classes.

This is just one example of how I reacted to a problem student. While each case is different with these students, I still maintain that depersonalizing the situation and

helping them to realize that they had the power to determine how I reacted to them was the approach which always worked best.

The rest of the behavior problems which I encountered in my classroom came from actual behavioral disorders. Several of my students had ADD/ADHD, some worse than others, and other students were in counseling for emotional and anger issues. The ADHD students could be picked out by their difficulty with paying attention, inability to sit still and tendency to always be in motion, and impulsivity. Two of them were medicated, one refused to take her medication, and one student's parents had decided on self-regulation instead of medication. While other students in my classes had similar behavioral problems, my reaction to students who's behavior was a symptom of their ADHA was different. While the behavior was never ignored, I was more careful to help them recognize the times where their difficulties got in the way of their learning. Oftentimes they simply needed a good deal of reminders to keep them n track. I found that it was best to keep these students in the front of the classroom where they could be most likely to interact with me, instead of turning their attention to other students or distractions in the back of the classroom. I also worked extremely hard to engage them in demonstrations and other interactive activities, and gave them specific tasks to focus their attention on. For example, if a student was getting especially antsy and was having a difficult time sitting still, I would have them help me hand papers out, collect papers, erase the board, set things up, etc. They enjoyed the attention, felt helpful and involved, and got a chance to move around. In any situation which calls for classroom managements skills, it is important to recognize the root of the students' behavior. In the case of these ADHD students it was a chemical or biological issue, and not an attitude

problem or lack of personal motivation and drive, which caused their behavior. Friendliness and a sense of teamwork helped them more than sending them out to the hall by themselves ever would.

Other students had emotional and behavioral issues which certainly affected their classroom behavior. According to one guidance counselor, I had "three of the five most difficult sophomores" in my AE biology class. Two of these students had anger and violence issues. Both were suspended for at least one week for outbursts against teachers and other students. It is not a surprise that these students were the most difficult for me, a student teacher, to react to considering the fact that they were being treated by professional counselors for their emotional problems. It was often difficult to react effectively to their defiance and aggression. In time I realized that the best way to approach their issues was to develop a personal relationship with them. My AE classes usually started with a teacher-directed lecture, review or discussion and ended with some sort of individual or group work. During the end of the class I usually permitted my students to use any of the work surfaces in the classroom. This was usually the best time to approach students who appeared to be upset or have a chip on their shoulder. I would approach them on the premise of checking on their progress and open a conversation with "So how's it going lately?" Over time as these students got to know me and trust me, a few of them opened up about what was going on in their personal life. Two students would mention their counseling sessions and what their counselors said to work on, and one student told me his parents were going through a difficult divorce. While I did not feel prepared to launch into long conversations about their emotional issues and counseling sessions, I did appreciate the fact that they opened up to me. I realized that

their negative behavior or lack of effort often came from tiring and frustrating stress in other parts of their life. I made sure that they knew that I was their biggest cheerleader, and that I held them to high standards which I was confident they could reach in class. I asked them what they needed or what we could do as a team to make class less frustrating and get focused, and tried to accommodate them or make compromises. While they were expected to do all of the same work in the same time as their classmates, I appreciated the fact that there were some days when these students wanted to work by themselves, or did not want to be called to the front of the classroom to demonstrate something. This led to a relationship of trust between these few students and while none of their behavioral problems completely went away, they I did see some improvements in each of them. As the trust and communication developed between us, they became somewhat less stressed, and more focused and respectful.

Whenever I was confronted with a student whose behavior or performance was becoming a serious problem, parents were contacted. I only had to do this a couple of times, and it made a great difference on both occasions. One of these students was a girl who distracting the class as she sought attention, and the other had missed so many classes that he had fallen far behind with make-up work which he was not completing. Unfortunately, there were some students in my class whose parents did not play an active role in their children's schooling. One of my students who had been suspended and showed a great deal of aggression had a lack of support at home. While my mentor had attempted to work with the student's parents at the onset of the year (I did not start my practicum until February), he had never been able to get their support. It seemed that the student's father was not present, and his mother was always either too busy or

uninterested in her son's performance. The lack of expectations from his parents did nothing to increase the student's motivation. As I mentioned previously, another student's parents were experiencing a messy divorce, and the student seemed to be caught up in the crossfire. While the situation did not seem to be affecting my student's performance in class, it did explain the days when he seemed depressed or anxious. When these students seemed to be having bad days, I gave them openings to talk to me if they needed a listening ear, which they sometimes took me up on. Usually, I let them go about their business and did not call them out too much in class.

To add another item to the list of management issues to be concerned with, there was always the question of how to respond to students who were absent. My general policy was that if a student was absent, any homework which they were not present to hand in was due the day they came back. If there was homework that was due that day, they still had to hand it in. If they had missed a lecture I told them to borrow someone's notes to hand-copy or photocopy in the teachers' office, and suggested that they stay after with me. Any quizzes which were missed were either made up during class or after school if it was inconvenient to take it during the class period. Tests were made up after school as soon as possible.

If students were absent for more than a day, I usually was more insistent that they stay after school. If they missed several important lessons, I often told them that they could not make their test up until they had reviewed the material with me. Three of my students missed more than a week's worth of classes due to vacation or suspensions. For these anticipated absences I gave them a list of textbook reading and practice problems/worksheets to complete. Once they got back to school they usually had to stay

after with me at least once or twice before they could make any tests or quizzes up. All labs were made up after school. The only exception to this mandatory after-school session was with an AE student who had been suspended, had not completed the work I gave him while he was out, and made little effort to stay after with me. I told him he had two days to take the test after school. While it seems as though I should have been more insistent about him staying after for extra help, the reality of this student's situation resulted in him telling me the only way he would stay after was to make a test up. I figured that the sooner he could take it, the less he could forget about the information, and he took it on his second day back. When students were absent for a long time and were attempting to prepare themselves to take a test, I gave them a day or two to review and get any questions they had for me answered.

Education experts and psychologists often stress the importance of a teacher's ability to be flexible and multi-task. Even in my four months of teaching, I learned to appreciate this necessity. Between the many types of learners present in a classroom, the backgrounds and personal situations they come from, and the unexpected class management situations which arise, a teacher must be able to analyze and react to a variety of situations quickly and effectively. After being competent in a subject and able to design effective teaching materials, the ability to cater to the individual needs of students and manage a class effectively is the next most important skill a teacher must have. This need is reflected in the Professional Standards which all student teachers must reach before they are licensed to teach. This reinforces the importance of understanding the unique personalities, learning styles, behavioral issues, and learning needs of a class, as well as the impact which one's classroom policies and management style has on them.

Chapter 5 – Assessments

Assessments are an inescapable part of any education system, no matter what its structure and format may be. I used both summative and formative assessments to monitor my students' learning process. Formative assessments gave students and me a more continuous idea of how well students were learning during the unit. These took the form of both informal and formal assessments. Summative assessments were used at the end of units or the teaching of major topics to reflect how well students had learned throughout the unit.

Usually when the term "assessment" is used formal examinations and tests are the first things which come to mind, but it would be a poor a teacher who used only these methods to gauge their students' progress. While it is important to measure the overall success students had in learning at the end of a unit, it is essential that a more continuous means of assessment is used. If there is a problem with the teacher's instruction or the student's learning process, formative assessments will reflect these deficiencies. If students need more help with learning a certain topic than their teacher expects, it is best that the teacher realizes this before a final exam is given out. These assessments are also helpful from the student's perspective: if a student thinks he has spent enough time studying a chapter, it is much better for him to find out that he has not fully learned the concept when he still has time to study more and get help from a teacher. It would be the fault of the teacher if such a student had no idea that his study techniques were insufficient, and failed a test as a result. This type of situation is one of the reasons that continuous assessment is necessary. I provided ample opportunities for both my students

and I to assess their progress through each unit, and these assessments were both straightforward and constructive.

The formative assessments which I developed for my students fell into a wide range of activities, and were both formal and informal. The most informal means which I used was the asking of questions. This technique was helpful as both a way to engage students, and a way for everyone to see whether or not students had learned the material. All lessons were peppered with a great deal of questions which I posed to the class, and we never moved on until the answer was provided and explained. If no one in the class could explain the question to my satisfaction, we backtracked through their notes and I provided more in-depth explanations until my students told me they felt comfortable with the material. This proved to be an efficient and effective way of assessing and teaching my students.

Class discussions were another informal type of formative assessment which I used. While we often had loosely structured class discussions when I was teaching, I also directed more structured discussions which required the class to apply their new knowledge, and which helped me understand how my students could mentally manipulate new topics. During the chromosomal genetics unit in each of my classes, we had debates on ethical questions which medical treatment for various genetic diseases had caused. (see Appendix C1, p. 190-193). We read case studies as a class, and students had to answer questions and discuss their feelings about the bioethics of the cases. First, students had to break down into small groups and come to a consensus, and these groups then defended their points of view to the class. Students asked questions of each other, and used both their personal experiences and knowledge about biology to answer them.

These classes allowed me to see how well my students could apply what they learned in the classroom to real-life medical situations. The debates also showed me how comfortable my students were with the material, if they were able to defend points to their classmates.

Some formative assessments were more formal, in that they were more structured and had grades assigned to them. Besides being valuable learning tools, worksheets and homework assignments were also a wonderful way to assess what students had learned. Sometimes we simply reviewed the worksheets or problems as a class, sometimes they earned credit on the basis of completion, and sometimes the assignments were collected and corrected by myself. The formality of the assessment depended on the place in the learning process which students were supposed to have reached, and the relative importance of the topics covered in the assignments in the scheme of the unit. Any of the worksheets or problem-based assignments included in the Appendix served as formative assessments of my students' learning process. The questions found at the end of each lab handout are included in this category. Lab activities involved the process of students applying previous knowledge to new lab techniques which they were in the process of learning. The questions were mostly knowledge- and skills-based short-answer questions. Labs were always collected and corrected, and students knew that the questions they were asked in labs could be seen again on their final unit tests. These labs were an excellent way for me to see how confident students were with new topics. If students could apply their new knowledge or general concepts to a specific situation or context in the lab, then they have successfully learned the topic. If they could not explain it well, they obviously needed more study time or further review with me.

The most formal of the formative assessments were the regular unit quizzes. During each unit, my students took at least one quiz (units with an especially broad base of material, such as the "Protein Synthesis" unit, included two). The quizzes which I developed usually took between fifteen and twenty minutes, and always included a variety of different question formats. A mix of matching questions, fill-in-the-blanks, diagrams to be filled in, and short answer questions could be found on quizzes in both levels. Honors quizzes tended to require more conceptual knowledge as well as a wide base of factual knowledge, while AE quizzes focused more on which terms and ideas the students had learned. This difference was reflected in the fact that honors quizzes included essay questions which focused on the ideas or mechanisms behind the key terms, and had matching sections where there were several more possible answers for each of the questions. AE tests had more questions about the definitions of specific terms, and always had word banks for fill-in-the-blank questions. Also, AE quizzes usually included diagrams which were identical or similar to diagrams which they had seen before in class which needed to be filled in. Graphic portions of tests were especially helpful for students who were slow readers, or who were visual learners. These quizzes were an excellent mid-unit assessment of what students had learned. While all information on the quizzes was likely to reappear as a test question the format and detail was less intensive than the tests, especially for honors students.

Overall, the main characteristic of formative assessments is that they are meant to reflect the point in the learning process which students have reached. Summative assessments serve a different purpose. These tools reflect the total level of learning which the students achieved over the period of time given to learn the material. While

formative assessments occurred quite often and in many forms, summative assessments were formal assessments which took relatively few forms. The only real summative assessments which I provided were reports and unit tests. The reason that there were far fewer summative assessments overall is because their purpose is to provide final representations of what students learned in a given time, and "final" assessments can only really be given once at the end of a unit. While formative assessments can be given continuously, there are only a few times during a unit when summative assessments are appropriate.

Two formal written reports were assigned to my honors students, over the course of two separate units. The first was a report about a genetic disease of the students' choice. Each student was required to research any genetic disease they chose and report on the various symptoms and characteristics, as well as how the various topics in genetics we were studying applied to the specific disease (see Appendix C1, p. 194). This was after I had given a lecture about how genetic counselors help give families guidance on the possible genetic traits of their children as well as treatment plants for children with genetic diseases, and the debates on ethical questions regarding these treatments. The report they wrote showed how they had learned to apply the genetic concepts they had used to the work a genetic counselor would do, and how they had understood the impact which these diseases have on peoples' lives. The assignment also gave my students a chance to showcase their writing skills. The second writing assignment for my honors students was a formal lab report on our "Natural Selection" lab (see Appendix E, p.253-259). While the experiments in this lab were done as a class or in groups, the reports were written individually. The handouts which I gave them contained introduction and

results sections which I had written. My students essentially "added on" to this handout by writing the results and discussion sections. These sections were based on questions and parameters which I had given them, fit into a proper lab report format which I had discussed in class. This was during the "Evidence of Evolution" unit. Natural selection plays such a huge role in evolution that I felt I could not adequately assess how well they had grasped the concept through a test while still covering all of the other information from the unit. This report allowed me to assess my students on their knowledge of the one topic without taking away from summative assessment on all of the other aspects of the unit. The report also developed their technical writing abilities.

The only other true summative assessments which I gave were seven tests, each at the end of a unit. These tests played the same straightforward role in each level, which was to show whether not students had a well-rounded and complete knowledge of the material presented throughout the unit. While their roles were the same, tests in the two different levels followed rather different formats. Honors tests were made up of mostly multiple choice questions. These questions tested their knowledge about facts and terms, reasoning skills using material from the unit, ability to apply the knowledge to experimental situations, and understanding of real-life applications of the knowledge. Sometimes the honors tests included essay questions which showed a deeper understanding of the conceptual and theoretical side of biology. These tests were a manifestation of the expectations for honors students, who should be able to learn a large amount of facts about a topic as well as conceptualize the underlying topics and issues involved in the topic.

AE tests always had a larger variety of types of questions, the most prevalent of which was always multiple-choice. Some advantages to multiple-choice questions are that they allow one to test a wide range of knowledge, as well as higher-order thinking[7]. Because most AE students are not as adept at answering multiple-choice questions as the honors students, a few different types of questions were also included on their tests. Fill-in questions with both sentences and whole paragraphs were often present on their tests. These questions help put the words into context, which usually made it easier for the students to connect terms with their definition or description. These sections always had word banks. This was owing to the fact that while many students actually knew the meaning of a term, they had difficulty recalling many definitions and terms in one test period. I also had to give these word banks to several students because of their IEPs. Because I gave them extra words so that they could not determine any answers by simple process of elimination, the word banks helped to jog their memories without giving them "easy answers". Sections where students had to match terms in one column with words or phrases from a second column were also on most of my AE tests. These questions served the same purpose as the fill-in questions, they simply used a different format. AE tests did require some writing of students in the form of short-answer questions, but no extended answers were ever required. The longest answers were usually about three sentences. These questions required students to conceptualize the topic a little more, and were usually the most challenging questions for these students. They provided a culminating assessment on how well the students understood the deeper meanings and

[7] Osterlind, Steven J.. Constructing Test Items: Mulsiple-Choice, Constructed-Response, Performance, and Other Formats (New York: Klewer Academic Publishers), p. 164.

implications of the ideas and concepts we had learned in class. It also reflected how well they had followed class discussions about these concepts.

Tests in both levels often included practical sections. These were certainly the most interesting and sometimes the most challenging sections of the tests for students. These portions basically asked students to use some sort of material or lab tool to answer short-answer questions. An honors test had a question about comparative anatomy is one example of these questions. Students were presented with an extremely wide variety of remains of organisms, and had to find pairs of analogous and homologous structures, as well as describe hypothetical situations in which one structure could evolve from another. In an AE test about mitosis students had to look at two slides under a microscope, decide which stage of mitosis which they saw in each, and explain how they came to this conclusion. Students told me that they liked the practical portions because although the questions were challenging, they got them out of their seats and allowed them to show what they learned during labs and demonstrations. Since they felt those were the most memorable lessons, they felt more comfortable answering questions about them. As a teacher, I appreciated the ability to assess students on practical skills, play to the more kinetic learning styles, and watch my students become a little more comfortable during testing sessions.

It is clear that students can benefit greatly from their teacher's ability to integrate assessment into classroom lessons. It is not only the assessments which the teacher devises which must be considered during classroom lessons, but also assessments provided by the state or federal government. WRHS students must pass the mathematics and verbal MCAS tests to graduate, and now take a biology MCAS as a reflection of

knowledge but not as a requirement for their diploma. It is not the intention of the developers of these tests that teachers spend time teaching students specifically for these tests. Rather, performance on the MCAS is meant to be a reflection of how well students have mastered the material included in the state frameworks. Because I designed the curricula for my units with the frameworks in mind, I was always preparing my students for the MCAS test as well. I feel that this is the appropriate way to treat the MCAS test, and that it is inappropriate to dedicate a great amount of time specifically to "MCAS review." As far as I was concerned my students understood the points of the lessons, they would perform well on the MCAS test. All assessments which I created to test their knowledge of classroom material therefore reflected their potential achievement on MCAS exams. The only students who I would be concerned about passing the MCAS would be students who were failing my class. I feel that even with these students, it is inappropriate to spend time teaching them "MCAS skills" to help them pass the tests. If they could not pass the MCAS, they clearly did not understand the prescribed knowledge in the frameworks, and had not earned a diploma. Teaching to the MCAS defeats the purpose of the MCAS, which is to reflect whether or not teachers are teaching all of the frameworks and whether students are learning the material well enough. I feel that it is far less likely for biology teachers to spend time focusing on upcoming MCAS exams since the biology MCAS test is not a requirement for graduation. As I was confident in my teaching of the frameworks, I was confident that my students were prepared for the MCAS exam without me directing much attention directly to them. The only day that I dedicated class time to the MCAS was on my final day, when I gave them an overview of the ecology frameworks at the request of my mentor who was concerned that they would

not have time to cover it thoroughly enough. The only materials which I developed for this lesson were the lecture notes which I presented to my students.

Teachers must be able to demonstrate flexibility in all areas of instruction, assessment being no exception. There are countless methods which one can use to assess their own instruction as well as students' learning and performance. Flexibility is necessary so that teachers can try different methods of assessment until the most effective for a certain group and topic are determined. The two greatest skills which a teacher must develop to do so are the ability to determine the appropriate form of assessment when testing different types of knowledge, and designing the test to be as reflective as possible of how each student is doing in the class. As a student teacher, I developed a range of different assessment skills and materials. I believe that my short months of experience allowed me to develop a degree of flexibility in trying new ways of assessing, and develop some skills in identifying and creating appropriate assessment tools.

Chapter 6 – Final Reflection

In completing this summary of my student teaching practicum at Wachusett Regional High School I have found a great sense of accomplishment and, more importantly, a better appreciation for the entire process. The practicum in and of itself is a great accomplishment, but there are a great many unexpected and unseen achievements which one experiences along the way. Appreciation is not simply for the magnitude of this undertaking or the opportunity to do so, but for the many skills and characteristics, some very subtle, which one develops in the process of a practicum.

My first aim in writing this paper has simply been to document the process and completion of my practicum. The first step of this practicum came before I ever began to teach a class. Before one can teach a class, one must have an understanding of its scope and purpose. There were many ingredients which defined the classes I taught, such as the class curriculum, the state biology frameworks, and the WRHS goals and mission. Once I began to observe students in these classes, I realized that there is a second set of influences which mandate the way in which a class must be taught. These are factors such as the students' backgrounds, their community, their difficulties and abilities, and their goals as students. Without taking time to recognize the presence and importance of these factors, one cannot provide insightful and effective instruction.

The beginning of lesson planning and teaching marked the onset of a great many lessons for me as a teacher. This paper has hopefully documented my abilities as a teacher, as well as indicating some of the learning processes which led to development of these abilities. I feel that my ability to teach biology is reflected in the lessons I designed, and my unique approaches towards different topics in biology and the diverse

styles of learning, abilities, and personalities in my classes. Not only do the notes, lesson plans, and course materials I created reflect my ability to teach to the frameworks which I identified as my standard and goal, but also my ability to teach the specific students in my class. The materials I developed were relevant and instructional, and were also interesting and challenging to my students. These two aspects of lesson design are extremely important, and I certainly learned a great deal about the skills, tools, observations, and reflection which are necessary to satisfy both aspects of course design. I also learned a great deal about developing assessments which are both effective and accurate. Experience in using assessments as teaching guides was one aspect of my practicum which I had not anticipated focusing on, and as my ability to design good assessments and interpret the results increased, I feel that my overall performance as a teacher improved as well.

As a college student, I was faced with the great intellectual challenge of learning to prioritize, organize, and present information. Though I understand biology to a much deeper degree as college biology major, I found that one must delve very deeply into information to be able to teach it even at a more basic level. Teaching certain topics to high school students has certainly increased my own competency, and providing education to others has helped me to appreciate the value of my own education.

Finally, as a future teacher I have gained a great sense of excitement and confidence towards my career. While I now appreciate to a much greater degree the challenges which I will face and the many skills which I have yet to learn and develop to become an effective teacher, I can say with confidence that I am prepared for this learning process and that I have even taken my first few steps on the learning curve.

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Wachusett Regional High School Science Department Archives, February-June 2007.

Appendix A – Honors "Protein Synthesis" Unit

This appendix contains all lecture notes, overheads, worksheets, labs, and assessments for the Honors "Protein Synthesis" unit.

Honors Protein Synthesis
Lesson Plan

Day 1:
Lecture 1: Review of DNA structures and DNA synthesis

Day 2:
Lecture 2: "From DNA to Proteins"

Day 3:
Lecture 3: "Transcription & Translation"
"Worksheet 19-2 – RNA & Protein Synthesis"* (finished for homework)

Day 4:
Review of lectures 1-3 and homework
"Figure out the codons and amino acids"* worksheet as a class
"Outlining the Steps in Protein Synthesis"* worksheet as a class

Day 5:
"tRNA & Protein Building"* lab

Day 6:
Review of lab, worksheets and lectures
Quiz on lectures 1-3

Day 7:
Lecture 4: "Gene Regulation"
"Operons" worksheet

Day 8:
Review of quizzes and entire unit
"Protein Synthesis" video

Day 9:
Unit Test

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Honors Bio – **B**

Protein Synthesis, Lecture 1: REVIEW OF DNA (Ch 1.10-12, 8.3-4)

DNA

- "deoxyribonucleic acid'
- contains hereditary information of most organisms
- **Nucleic acid**: **double-stranded sting of nucleotides**

Nucleotide:

- 1 Deoxyribose sugar – 5C sugar
- 1 Phosphate group
- 1 **nitrogen-containing base**
    1. Cytosine
    2. Guanine
    3. Thymine
    4. Adenine
  - A—T & C—G….they pair because of their molecular shape
    A & G: double-ring
    C & T: single-ring
  - N-bases connected by **H-bonds**
    2 for A—T
    3 for C—G
  - **Continuous diameter** is maintained since 1 is short and 1 is long

- **Antiparallel structure –** backbones have parallel but opposite orientations (*important for replication)
- Double helix structure – discovered by **Watson & Crick**/Rosalind Franklin & Maurice Wilkins
    - Franklin & Wilkins: X-ray diffraction studies took "pictures" of DNA
    - Watson & Crick: proposed model for DNA molecule based on pictures (1953)
    - 1962 Nobel Prize to Wilkins, Watson & Crick

DNA SYNTHESIS

- DNA replicates in the S phase of cell cycle
- Three steps
    1. Enzymes bind to DNA
    2. Enzymes unwind double helix
    3. Two new strands of DNA synthesized

1. Proteins bind to DNA

- Bind at the **replication origin** – parts of chromosome (>1 on each) where synthesis starts
- **Replisome** – DNA + proteins at replication fork
    -Lots of proteins: Helicase, Stabalizers, Primase, DNA Polymerase, DNA Ligase

2. Protein unwind double helix

- **Helicase** – unwinds helix ("heli-" for helix + "-ase" for catalyzing enzyme)
- **Stabilizer proteins –** keep helix open

3. Synthesis

- **Primase** sets RNA Primer on strand ("prim-" for primer + "-ase" for enzyme
- **DNA Polymerase III** extends primer….synthesizes new strand by matching nucleotides to **template** (AT or CG) ("polymer-" for making a polymer, "-ase" for enzyme)
    - Starts at RNA primer
    - Moves in both directions
    - Creates new strand from **5' → 3'**....discontinuous because they're antiparallel

        - **Leading strand** – continuous, starts from 3' end of template (overall 3'→ 5' of template)
        - **Lagging strand** – created in pieces, starts on 5' end of template (overall 5' → 3' of template)

- **Okazaki fragments** – fragments DNA Polymerase III makes on lagging strand
    - discovered in 1968 when team led by Okazaki were studying *E. coli*
- **DNA Ligase** – fills in between Okazaki fragments

*** Two new strands of DNA!**

- Each is a new double helix
- **Semi conservative replication -** 1 template strand + 1 new strand…..half is old, conserved DNA
    - **Meselson & Stahl** – confirmed semi conservative replication in 1958 with *E. coli*

Honors Bio – **B**

Protein Synthesis, Lecture 2: From DNA to Proteins (Ch 1.9, 9.1-2 & 4)

***So we know DNA contains "information"….how does that work?

IIa. GENES

- Code for all hereditary information
  → code for **proteins!**
- Can be found on both sides of double-stranded DNA

*** Why do you need DNA? DNA's **genes → PROTEINS**

- **Codons =** 3-base sequences that code for specific **amino acids**

IIb. PROTEINS

- Many functions:
  - Structure (skin, connective tissue)
  - Movement (muscles)
  - Transport (membrane proteins)
  - Communication (hormones)
  - Catalysts (metabolism…and DNA synthesis!)

- **Amino Acid =** monomer
  - 20 amino acids
- **Polypeptide =** polymer
  - Amino acids bonded covalently….these are **peptide bonds**

- Role determined by structure
  1 ° - sequence of **amino acids**
  2 ° - chain folds and twists
  3 ° - complex **folding** to become globular… "3D" structure

  * Denatured proteins have broken chains (1 °) or are unfolded (3 °)

***How do we go from bases/genes to proteins?.....RNA!

DNA ----------→ Proteins = **PROTEIN SYNTHESIS**
RNA

IIc. RNA

- "Working copy" of genetic code
- Nucleotide
    - **Ribose**
    - Phosphate group
    - N-base
        Uracil – single-ring, goes with Adenine
        NO Thymine!

- Complementary to DNA
- Single Strand, folded up into 3 different Structures:

1. MESSENGER RNA

- mRNA
- Goes between nucleus & cytoplasm

- Only one that takes info directly from DNA
-

*** What do genes look like exactly? (reason through this…it must be a set of bases)

- **Codons =** 3-base sequence which codes for proteins

2. RIBOSOMAL RNA

- rRNA
- Most common kind (80%)
- Huge!

- rRNA + Proteins = Ribosomes (remember the rough E.R.?)

- Has 2 sub-units

3. TRANSFER RNA

- tRNA
- Carries amino acid to ribosomes

- Each is specific to **one** type of a.a.

- **Anticodons =** tRNA triplet that matches up with an mRNA codon
    - Opposite of the codon (…"anti-")

***So what makes RNA different from DNA?

DNA	RNA
Deoxyribose	Ribose
Thymine	Uracil
Double-stranded	Single-stranded
Double-helix	Folded
Only in nucleus	Nucleus/cytoplasm/ribosomes
Genetic code → RNA	DNA → Protein
	3 types (m, r, t)

Next up: How RNA is made, how you get from there to Proteins**

Honors Bio – **B**

Protein Synthesis, Lecture 3: Transcription & Translation (Ch 9.3-5)

***So now we know about DNA, RNA, and Proteins. Now let's get some arrows in there….HOW DOES PROTEIN SYNTHESIS WORK??

IIIa. TRANSCRIPTION

RNA SYNTHESIS

- **RNA Polymerase =** enzyme that assembles strand of RNA based on a DNA template, so that the RNA's nucleotides are complementary
  - 1 kind in prokaryotes, 3 in eukaryotes

- **U ---- A** (No thymine! **T-X-A)**
- Happens in the **nucleolus**

- tRNA folds up, rRNA + proteins (~70!) are made into ribosomes

- 3 Steps:

1. Initiation: RNA polymerase binds to DNA strand,
- **Start codons** = right in front of the coding segment

- Initiation factors = proteins that help this happen in eukaryotes

2. Elongation: RNA polymerase unwinds part of DNA, assembles strand of RNA by matching bases on nucleotides
- Moves away from promoter region

3. Termination: RNA polymerase releases DNA and RNA strands, DNA winds back up
- **Stop codons =** after the coding segment ends, where RNA polymerase lets go

*** RNA in nucleus up to 200,000 nucleotides. Human ave = 5,000.
RNA in cytoplasm = 1,000…..why???

RNA PROCESSING

Enzymes in nucleus add/remove/modify nucleotides after RNA synthesis

*__mRNA:__

- **mG Cap =** Guanine nucleotides (methyl-guanine or mG) added on front end
    - Protects
    - Helps attach to ribosomes for translation

- **Poly-A Tail =** 100-200 Adenine nucleotides replace end
    - Protects
    - May help them travel through membrane
    - Longer poly-A tail → longer the RNA lasts (cloning)

***For 3 lectures we've talked about making DNA and RNA. what about PROTEINS?!

IIIb. TRANSLATION

Remember: DNA has codes, mRNA carries the codons, tRNA has anticodons and amino acids, rRNA can grab them both

- tRNAs are **charged** by 20 enzymes
    - 1 for each a.a.
    - uses 1 ATP

- mRNA attaches to rRNA

- tRNA anticodons attach to mRNA codons
- amino acids are right next to each other, rRNA starts forming the chain

→ the CODONS are coding for the POLYPEPTIDE (order of a.a.s!)

- **Start codon = AUG** ← there are no tRNA anticodons for these
- **Stop codons = UAA, UAG & UGA**

Honors Bio – **B**

Protein Synthesis, Lecture 4: Gene Regulation (Ch 9)

So we know the basics about protein synthesis…but we've got a little bit more to talk about…

IIId. Splicing

- Removing sections and mending the break
- **Introns =** non-coding parts (cut out)
- **Exons =** coding part

exon -------- GU –intron – AG ----------exon

- Often done by proteins, can be by other RNAs in organelles and unicellular eukaryotes
- Very important – mistakes can be devastating

***How can we be sure that each gene codes for only 1 enzyme?

IIIc. ONE GENE/ONE ENZYME

- Beadle & Tatum
- Procedure: created mutated mold cells that differed by 1 gene
    - Some cells needed specific vitamins/amino acids since they couldn't break it down themselves.
    - Strains couldn't perform all of the steps in metabolic pathways
        - Couldn't produce substances that came after certain point
        - Had accumulation of most synthesized substance at that point

Metabolic Pathway: A----------> B----------->C----------->D
Enzyme 1 Enzyme 2 Enzyme 3

Strain 1: no Enzyme 1
Ax B----------->C----------->D
Strain 2: no Enzyme 2
A----------> Bx C----------->D
Strain 3: no Enzyme 3
A----------> B----------->Cx D

- Now: "One gene, one Polypeptide"

***We know how to synthesize polypeptides, but how do they get their specific structure?

IIIe. MODIFICATION OF PROTEINS

- By enzymes
- In cytoplasm

- 2 Ways**:**

Chemically

- Enzymes often add sugars
  - Glycoproteins
  - ex. Receptors in cell membranes
- Cut into pieces
  - Activates some proteins
  - ex. Pepsin, trypsin…

Physically

- Structure is important!
- Chaperone proteins help proteins fold into shape

IIIf. MUTATIONS

- Translation errors → bad proteins
- Probability:
- Usually recognized and destroyed by cell/body (protosomes)

- Reasons:
  - Transcription/translation errors
    - DNA is misread
    - Even 1 missing/extra shifts entire frame
    -
  - Bad DNA
    - Missing/extra nucleotides → frame shift
    - Wrong nucleotide → wrong a.a., stop/start, mistake intron/exon
    -
  - Lack of amino acids

***Do all cells need the same stuff? NO

***How do we control where proteins go???

IIIg. After Synthesis…

- Protein gets packaged by Golgi, goes to final location in/out of cell
- **Signal sequence =** set of amino acids at end of protein chain that tells cell where it should go

***How do we control what genes get expressed?

IVd. GENE REGULATION

- Different cells need different "stuff"
- Regulated by:
  - Available amino acids
  - Messages from other cells
  - Hormones
  - REGULATORY MECHANISMS
  - Protein survival time affects # in cell

OPERON HYPOTHESIS

- Jacob & Monod, (1961)
- Worked with the *lac* operon in *E. coli*
- Parts:

Regulator Gene = on DNA, makes repressor molecule
↓
Repressor Molecule = binds to inducer or operator gene
↓
Operator Gene = decides if structural gene is turned on
&
Inducer = molecule to be catalyzed
↓
****Structural Gene =** produces enzymes that break lactose down

- If lactose is absent…
  Repressor molecule binds to the **operator gene**, which shuts the **structural gene** off….so enzymes that break lactose down aren't made

- If lactose is present…
  Repressor molecule binds to lactose molecules, so **operator gene** is open and **structural gene** stays switched on….enzymes that break lactose down are made.

- WHY? If the cell doesn't need to be breaking lactose down, it's a waste to make the enzymes

Name _____ Class _____ Date _____

ACTIVITY 19-2. RNA AND PROTEIN SYNTHESIS

In the replication of DNA, existing strands serve as templates for the synthesis of new complementary strands of DNA. Strands of DNA also serve as templates for the synthesis of a type of RNA called *messenger RNA*, or *mRNA*. The mRNA then serves as a template for the assembling of amino acids, which bond together to form polypeptides and proteins. Thus, the sequence of nucleotides in the DNA determines the sequence of nucleotides in the mRNA, which in turn determines the sequence of amino acids in proteins. Two other types of RNA are involved in protein synthesis. These are ribosomal RNA (rRNA) and transfer RNA (tRNA).

structure of RNA

Like DNA, RNA is composed of nucleotide subunits. Unlike DNA, RNA is single-stranded, and the sugar it contains is ribose instead of deoxyribose. Also, instead of the thymine that is present in DNA, RNA contains the pyrimidine uracil, which is complementary to adenine.

Question

How does the structure of RNA differ from that of DNA?

synthesis of messenger RNA

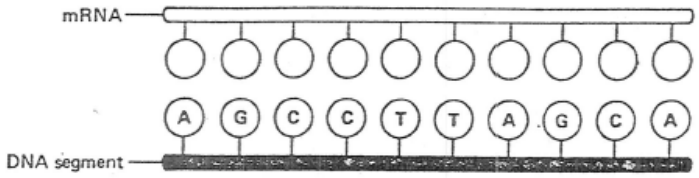
Like the replication of DNA, the synthesis of mRNA involves a complex series of enzyme-catalyzed reactions. It begins with the attachment of a particular enzyme to a special site on the DNA molecule. This causes the two strands of DNA to unwind in that area. It is thought that only one of the two strands of DNA serves as a template for RNA synthesis. The RNA nucleotides (ribonucleotides) align along the DNA strand, forming a complementary strand of mRNA. The process by which the hereditary information of the DNA is copied into the mRNA is called *transcription*. The pairing of bases in mRNA synthesis is the same as in DNA replication except that where there is an adenine on the DNA, there is a uracil on the mRNA. Messenger RNA is a short-lived intermediate in protein synthesis. It can be synthesized very rapidly and broken down just as rapidly. From the nucleus where it is synthesized, the mRNA passes into the cytoplasm and becomes attached to ribosomes.

Questions

1. In what part of the cell does the synthesis of mRNA occur?_____
2. What determines the sequence of bases in mRNA?

3. Messenger RNA migrates from its site of synthesis and becomes attached to _____.

4. The diagram below shows the sequence of bases in a segment of DNA. Fill in the bases for a complementary segment of mRNA.



ribosomal and transfer RNA

Ribosomal RNA, along with some protein, makes up the ribosomes. Transfer RNA, found in the cell cytoplasm, picks up amino acids and carries them to the ribosomes. Both rRNA and tRNA are stable components of the cell. They are not continually synthesized and broken down as is mRNA. Like mRNA, tRNA and rRNA are synthesized by transcription of the DNA template.

Questions

1. The three types of RNA found in the cell are _____, _____, and _____.
2. Ribosomes are made up of _____ and _____.
3. Amino acids are carried to the ribosomes by _____.

the genetic code and protein synthesis

The genetic information is encoded in the sequence of nucleotides in the molecules of DNA. The same information is encoded in the nucleotide sequence of messenger RNA. The code itself consists of specific sequences of three nucleotides. Each such triplet, or *codon*, codes for a particular amino acid. Some amino acids are coded for by more than one triplet. For example, the codes for the amino acid lysine are AAA and AAG.

Protein synthesis takes place at the ribosomes. Here, the mRNA from the nucleus acts as a template for the assembly of amino acids. The sequence of bases of the mRNA determines the sequence of amino acids. Each kind of amino acid (there are about twenty) is picked up by a specific transfer RNA and carried to the ribosome. The tRNA has a triplet of exposed nitrogenous bases that are complementary to a triplet of bases (codon) on the mRNA at the ribosome. This triplet of bases on the tRNA is called the *anticodon* because it is complementary to the codon of the mRNA. The tRNA carrying its amino acid becomes temporarily attached to the complementary triplet of the mRNA at the ribosome. In this way, a specific series of amino acids lines up at the ribosome. The order in which the amino acids are arranged is determined by the base sequence (triplets) of the mRNA, and ultimately by the base sequence of the cell DNA.

Class _____ Date _____

The amino acids at the ribosome are joined together by dehydration synthesis to form proteins. This is accomplished with energy from ATP and in the presence of specific enzymes. When the protein is complete, it separates from the tRNA, and the tRNA separates from the mRNA.

Questions

1. Where does protein synthesis occur in the cell?

2. What determines the sequence of amino acids in a given protein?

3. Why does a particular tRNA become temporarily attached only to a specific triplet of mRNA?

4. What is a codon?

5. The type of reaction by which amino acids bond together to form proteins is _____ _____.

6. Using the reference list below, determine the sequence of amino acids coded for by the mRNA shown below. (Start from the top of the mRNA.)

mRNA

C
G
U
A
A
A
U
G
G
A
G
G
G
U
A
G
A
A
U
U
C
A
A
G

AMINO ACID SEQUENCE

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Reference List:

AMINO ACID	RNA TRIPLET CODE
valine	GUA, GUG, GUC, GUU
arginine	AGA, AGG, CGA, AGA, CGC, CGU
lysine	AAA, AAG
tryptophan	UGG
glutamic acid	GAG, GAA
phenylalanine	UUU, UUC

Name _____ Date _____ Class _____

CHALLENGE

Chapter 7

FIGURE OUT THE CODONS AND AMINO ACIDS

Use what you have learned about pairing of nitrogen bases, and a biochemistry book to fill in the missing parts in the chart below. The first one is done for you.

Order of Codon in DNA	Order of Codon in mRNA	Amino Acid Coded for by mRNA
CTT	GAA	glutamic acid
GCA	_____	_____
_____	UCA	_____
CCT	_____	_____
_____	ACU	_____
GGG	_____	_____
_____	UAA	stop code
CAT	_____	_____
_____	AUC	_____
CGA	_____	_____
ATC	_____	stop code
_____	CAA	_____
AAA	_____	_____
ACT	UGA	_____
_____	UUG	_____
ATG	_____	_____
_____	_____	histidine
_____	_____	lysine
_____	_____	trytophan
_____	_____	methionine (and start code)

Name _____ Class _____ Date _____

Outlining the Steps in Protein Synthesis

Sequencing Events

Protein synthesis is a complex process. The sequence of events that occurs during this process begins with DNA that is located in the nucleus of a cell. In this activity, you will trace the steps that are involved in the protein synthesis of a part of a molecule of oxytocin.

Oxytocin is the pituitary hormone that helps to regulate blood pressure, stimulates the uterus to contract during childbirth, and stimulates the production of milk.

Below is a DNA sequence that could code for part of a molecule of oxytocin. Beginning at the arrow, 10 three-base groups are shown.

↓

ACA	ATA	TAG	CTT	TTG	ACG	GGG	AAC	CCC	ATT
1	2	3	4	5	6	7	8	9	10

Write the sequence of messenger RNA (mRNA) codons that would result from the transcription of this portion of DNA. The arrow marks the starting point.

mRNA:

↓

_____

Messenger RNA then attaches to a ribosome, where translation takes place. Each codon of mRNA bonds with the anticodon of a transfer RNA (tRNA) molecule. Each tRNA molecule also bonds with a specific amino acid. Table 1 shows the mRNA codons and the amino acids for which they code. Use your mRNA sequence to write the sequence of amino acids in this part of the oxytocin molecule. Begin at the arrow on page 55.

Table 1 mRNA Codons

First Base in Code	Second Base in Code: A	Second Base in Code: G	Second Base in Code: U	Second Base in Code: C	Third Base in Code
A	Lysine	Arginine	Isoleucine	Threonine	A
	Lysine	Arginine	Methionine	Threonine	G
	Asparagine	Serine	Isoleucine	Threonine	U
	Asparagine	Serine	Isoleucine	Threonine	C
G	Glutamic Acid	Glycine	Valine	Alanine	A
	Glutamic Acid	Glycine	Valine	Alanine	G
	Aspartic Acid	Glycine	Valine	Alanine	U
	Aspartic Acid	Glycine	Valine	Alanine	C
U	STOP	STOP	Leucine	Serine	A
	STOP	Trytophan	Leucine	Serine	G
	Tyrosine	Cysteine	Phenylalanine	Serine	U
	Tyrosine	Cysteine	Phenylalanine	Serine	C
C	Glutamine	Arginine	Leucine	Proline	A
	Glutamine	Arginine	Leucine	Proline	G
	Histidine	Arginine	Leucine	Proline	U
	Histidine	Arginine	Leucine	Proline	C

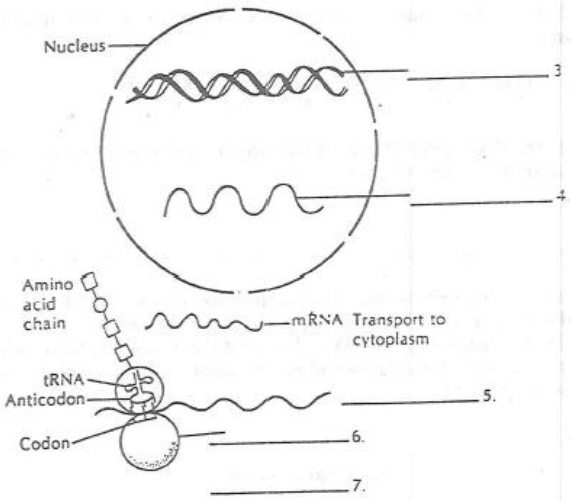
↓

1. How many amino acids make up this portion of the oxytocin molecule?

2. What is the purpose of the UAA codon?

On the diagram in Figure 1, label the structures that are involved in protein synthesis. Draw arrows to indicate the direction in which the genetic information moves during protein synthesis.

Figure 1



Complete the chart below. Give the name of and briefly describe the step in protein synthesis that occurs at each part of the cell.

Part of Cell	Name of Protein-Synthesis Process	Description
Nucleus		
Ribosome		
Cytoplasm		

tRNA And Protein Building

25

RNA produced in the nucleus of a cell moves out of the nucleus to the cell's ribosomes. This RNA is a specific sequence of bases copied from the DNA which carries the chromosomal genetic message to the cytoplasm. Thus, it is called messenger RNA (mRNA). At the ribosomes, mRNA directs the building of proteins. Proteins are made up of smaller molecules called amino acids. How does a cell construct the proper amino acids into protein molecules? Formation of proteins involves another kind of RNA. Transfer RNA (tRNA) brings specific amino acids to mRNA according to the code sequence of bases found on mRNA.

In this investigation, you will

(a) use paper models to show how base shapes in mRNA match only with specific base shapes of tRNA.
(b) use paper models to show how tRNA molecules bring specific amino acid molecules to the ribosome where building of proteins occurs.
(c) learn to transcribe a DNA code to a mRNA message and translate the mRNA to the tRNA—amino acid code.
(d) study the molecular basis for gene mutations.

Materials

models of RNA nucleotides from Investigation 24 page of paper models of tRNA scissors

Procedure

NOTE: Models from the previous investigation are needed for Part A.

Part A. Structure of tRNA

• Build a molecule of mRNA using the paper molecules from Investigation 24. Make sure you are using only RNA nucleotides. Join the RNA nucleotides to form a row of molecules in this order:

Guanine
Adenine
Cytosine
Uracil
Cytosine
Guanine

• Recall that molecules of mRNA leave the cell nucleus and move out to the cell's ribosomes. Meanwhile, transfer RNA (tRNA) is present in the cell cytoplasm. Models of tRNA were supplied to you by your teacher. Molecules of tRNA are composed of many base nucleotides. However, tRNA has a three base sequence (a triplet) that can match up with the bases of mRNA.

• Cut out the two models of tRNA. *Cut only along solid lines.* **CAUTION:** *Always be careful with scissors.*

1. (a) Name the four nucleotide bases present in tRNA. _____

(b) Do these bases differ from those found in mRNA? _____

(c) How does the tRNA molecule differ from mRNA in shape? _____

_____

_____

• Join the tRNA molecules to the model of mRNA.

2. What base in mRNA can only join with the

(a) adenine base of tRNA? _____

(b) uracil base of tRNA? _____

(c) guanine base of tRNA? _____

3. What order of bases on mRNA will match a sequence on tRNA of

(a) UUA? (uracil, uracil, adenine) _____

(b) UCA? (uracil, cytosine, adenine) _____

(c) UGA? (uracil, guanine, adenine) _____

(d) AAA? (adenine, adenine, adenine) _____

Transfer RNA picks up amino acids in a series of chemical steps. A tRNA molecule only picks up a certain amino acid. The amino acid is attached to the tRNA at the end opposite the three bases that will attach to mRNA.

• Cut out the two remaining models of amino acids, serine and aspartic acid, from the page provided by your teacher. Join these models to their proper tRNA models. Only a specific amino acid will fit along the top of each tRNA model. Remember that each tRNA model has a three sequence base called a triplet.

4. What amino acid connects to a tRNA molecule with a triplet of

(a) AGC? _____

(b) CUG? _____

5. What molecule receives the amino acids on tRNA? _____

6. How many base molecules or nucleotides of mRNA are responsible for the coding of one amino acid? _____

A small notch along the bottom of each amino acid will fit into a corresponding notch in the tRNA molecule.

Part B. Forming a Protein Molecule During Translation

When many amino acid molecules are brought to the mRNA by tRNA, the amino acids join to form a protein molecule. When tRNA molecules with their attached amino acids join to the bases of the mRNA, the formation of a protein molecule is begun. This entire process is called translation. The DNA message has been translated into a protein molecule.

7. What amino acid is attached to a tRNA molecule having a base sequence of

(a) UUU? (Read from Table 25-1.) _____

(b) GCU? _____

8. What tRNA triplet is needed to join with the following amino acids:

(a) phenylalanine? (Read from Table 25-1.) _____

(b) valine? _____

(c) glutamic acid? _____

Depending on the type and order of amino acids, an almost endless variety of proteins can be produced. Because of the repeated matching of base sequences, the base sequence in the DNA of chromosomes codes for and controls the formation of protein molecules at ribosomes.

9. A protein molecule consists of the following amino acid sequence: leucine, glutamine, tyrosine, leucine, serine, serine. What would be the sequence of tRNA bases responsible for forming this protein? (Use Table 25-1.) _____

10. A ribosome receives the following mRNA message: AAA, CGA, GAA, GUU.

(a) What will be the sequence of tRNA bases joining the mRNA molecule? _____

(b) What will be the sequence of amino acids formed from this code? _____

TABLE 25-1. tRNA TRIPLET CODES OF SOME AMINO ACIDS

AMINO ACID	tRNA CODE
Serine	AGC
Proline	GGG
Leucine	AAU
Glutamic acid	CUU
Tyrosine	AUA
Arginine	GCU
Glutamine	GUU
Phenylalanine	AAA
Valine	CAA
Lysine	UUU

As a review, you should now be able to transcribe (decode) a message in DNA base code into mRNA and then translate it into a protein molecule.

A portion of DNA on a chromosome has the sequence of bases along one strand of DNA as indicated in Table 25-2.

• Transcribe or decode this message first into mRNA code, then translate it into tRNA code and proper amino acids using Table 25-1.

TABLE 25-2. TRANSCRIBING AND TRANSLATING OF A DNA SEQUENCE

CHROMOSOME DNA CODE OF BASES	mRNA BASE CODE	tRNA BASE CODE	AMINO ACID SEQUENCE
AAT			
GGG			
ATA			
AAA			
GTT			

• Rework the cell's code language backward by completing Table 25-3.

TABLE 25-3. TRANSCRIBING AND TRANSLATING OF AN AMINO ACID SEQUENCE

AMINO ACID SEQUENCE	tRNA BASE CODE	mRNA BASE CODE	DNA BASE CODE
Proline			
Glutamic acid			
Lysine			
Serine			
Leucine			

Part C. Mutations and Base Sequence Errors

Not often are there errors in the process of forming proteins from the DNA code of instructions. An error in the process is a mutation and will result in formation of a different type of protein.

Hemoglobin is a protein in red blood cells. Hemoglobin results from the proper arrangement of almost 600 amino acids. Most humans have the correct type of hemoglobin. However, in some people the arrangement is incorrect. These people have a disease called sickle-cell anemia. Their red blood cells are sickle-shaped rather than round. As a result, the red blood cells cannot transport oxygen as well.

The following amino acid sequence represents a portion of the normal hemoglobin molecule: proline, glutamic acid, glutamic acid, lysine.

11. Translate the sequence of amino acids in normal hemoglobin into

(a) tRNA base codes. _____

_____

(b) mRNA base codes. _____

_____

(c) DNA base codes. _____

_____

In sickle-cell anemia, the sequence of amino acids is slightly different. It is proline, valine, glutamic acid, lysine.

12. Translate the sequence of amino acids in sickle-cell hemoglobin into

(a) tRNA base codes. _____

_____

(b) mRNA base codes. _____

_____

(c) DNA base codes. _____

_____

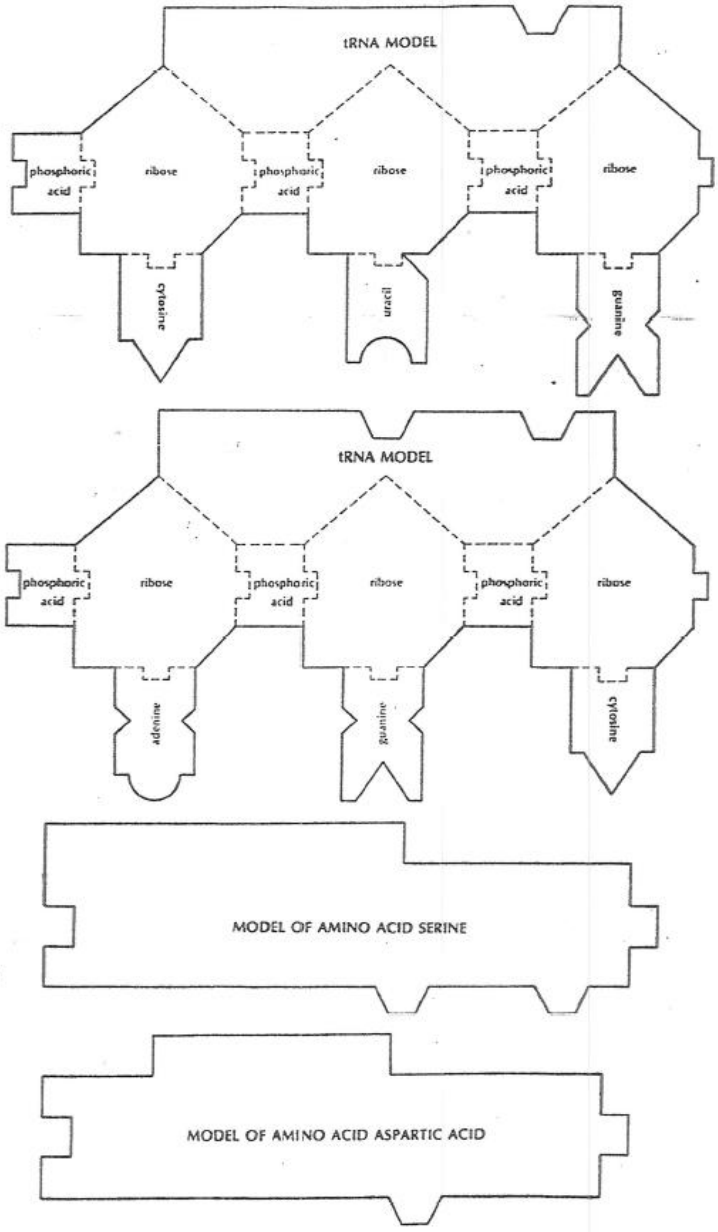
13. In terms of base nucleotides, explain the only difference between the DNA message for normal hemoglobin and the DNA message for sickle-cell hemoglobin. _____

_____

_____

SIMILARITIES AND DIFFERENCES BETWEEN mRNA AND tRNA		
	mRNA	tRNA
deoxyribose present		
ribose present		
phosphoric acid present		
adenine present		
thymine present		
uracil present		
guanine present		
cytosine present		
contains a chemical message or code		
carries an amino acid to a ribosome		

tRNA MODELS FOR INVESTIGATION 25, "tRNA AND PROTEIN BUILDING"



35T

Name:_____ Date:_____ Block:___

Honors Biology Protein Synthesis Quiz (22 pts)

1. What are the three steps in DNA replication?

2. What are three functions of proteins?

3. RNA stands for _____.

4. When the nitrogenous bases in RNA bind, _____ pairs with only_____, and _____ pairs with only _____.

5. What is the function of RNA polymerase?

6. During RNA processing, a _____ is added to the front of mRNA, and a _____ is added to the other end.

7. Give the name of each type of RNA and briefly describe their functions.

8. _____ carries codes for proteins from DNA to the cytoplasm in the form of codons, and _____ has anticodons which are complementary to these codes.

9. _____ is a start codon.

10. _____ is a stop codon.

OPERONS

- The structural genes for the metabolism of lactose are adjacent to one another on the chromosome and are all transcribed from one promoter (review transcription, Chapter 12). The operator overlaps the promoter and is the site where the repressor binds, which prevents transcriptional initiation by RNA polymerase. The regulatory sequences of the *lac* operon are the promoter, and the operator. The structural genes encode enzymes that metabolize lactose or transport lactose into the cell.

- In cells that are not exposed to lactose, the repressor binds the operator and the *lac* genes are not expressed. The *lac* operon is inducible (see Figure 13.13). An inducer of the *lac* operon (lactose and other β-galactosides) binds the repressor, which changes its tertiary configuration so that it can no longer bind the operator site. RNA polymerase initiates transcription and the structural genes are transcribed. The messenger RNA for *lac* structural genes is translated into protein and lactose can be metabolized (see Figure 13.17).

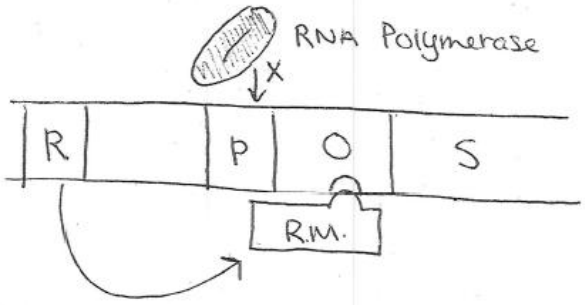
Inducer Absent

R= _____

RM= _____

O= _____

S= _____

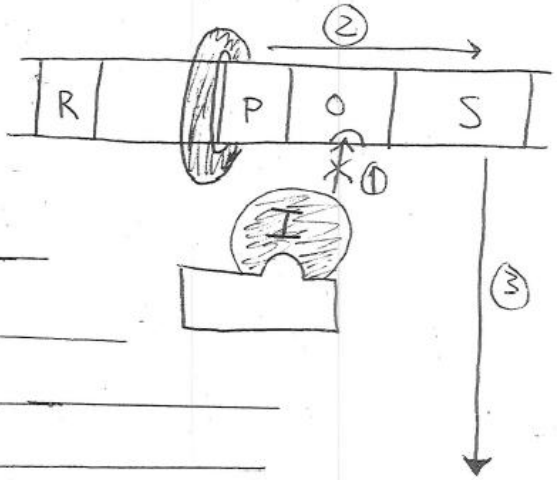


Inducer Present

1. _____

2. _____

3. _____



Enzymes that catalyze the breakdown of the inducer

Name:_____ Date:_____ Block:___

Honors Biology Protein Synthesis Test (100 pts)

The substance described below has characteristics of:

A. DNA molecules
B. RNA molecules
C. DNA and RNA molecules
D. Neither

1. ___ Contain ribose
2. ___ Are found in the nucleus
3. ___ Are found in the cytoplasm
4. ___ Can replicate themselves
5. ___ Contain all hereditary information
6. ___ Contain uracil
7. ___ Could be found in a virus
8. ___ The transfer type is folded
9. ___ Contain 5-carbon sugars
10. ___ Found mainly in the nucleus
11. ___ Composed of a specific amino acid sequence

The discovery below was made by:

A. Beadle & Tatum
B. Jacob & Monod
C. Watson & Crick
D. Meselson & Stahl
E. Okazaki

12. ____ DNA has a double-helix structure
13. ____ DNA goes through semi-conservative replication
14. ____ One gene can only code for one enzyme
15. ____ Operons can regulate the synthesis of some proteins

Match the proteins below with their functions.

A. Stabilizer proteins
B. DNA Polymerase I
C. Primase
D. DNA Polymerase II
E. DNA Polymerase III
F. Helicase
G. RNA Polymerase

16. ___ Sets RNA primers
17. ___ Assembles nucleotides to form new DNA strand
18. ___ Unwinds DNA's double-helix
19. ___ Unwinds DNA strand during RNA synthesis
20. ___Holds DNA strands apart during DNA replication

21. Genes indirectly control the synthesis of _____.
    a. lipids
    b. nucleotides
    c. proteins
    d. sugars

22. The specific protein produced in a cell is directly related to the…
    a. sugar and phosphate sequence in the DNA molecule.
    b. number of ribosomes in the cell.
    c. nucleotide sequence in the DNA molecule.
    d. number of mitochondria in the cell.

23. Why is the primary structure of a protein important in cell function?
    a. Because if it's wrong, the cell is doing something wrong in protein synthesis.
    b. Because the amino acid sequence affects how a protein is folded.
    c. Because the folding of a protein affects what it can do.
    d. It isn't, the tertiary structure is the only one that really matters.

24. If there was a mistake made in the sequence of nucleotides during DNA replication, it is reasonable to conclude that…
    a. enzyme synthesis is not affected.
    b. the mutation is harmful to the organism.
    c. the complementary RNA would also be altered.
    d. enzyme synthesis is not affected.

25. Proteins are an excellent mechanism by which genetic information is expressed because unlike sugars, lipids, and nucleic acids, proteins…
    a. can be metabolized to make energy to be used throughout the body
    b. can replicate themselves
    c. are easily transported in the body
    d. can be structural or catalytic molecules or may be involved in cell-cell communication.

26. Suppose that 30% of the bases in the DNA of a cell are cytosine and 20% are adenine. Which of the following describes the most likely percentages of the other two types of bases in the cell's DNA?
    a. 30% guanine, 20% thymine
    b. 30% guanine, 20% uracil
    c. 30% thymine, 20% guanine
    d. 30% uracil, 20% guanine

27. Transfer RNA becomes attached to messenger RNA by
    a. base pairing
    b. peptide bonds
    c. deoxyribose
    d. ribose

28. tRNA charging is when…
    a. tRNA charges the ribosome with a new amino acid.
    b. tRNA binds to an amino acid.
    c. tRNA binds to mRNA
    d. a new tRNA strand is folded into the correct shape.

29. In what situation does RNA play a similar role to enzymes?
    a. When tRNA carries amino acids around.
    b. When RNA polymerase holds the helix open.
    c. When mRNA carries codes out of the nucleus.
    d. When rRNA facilitates the binding of amino acids.

30. Messenger RNA becomes attached to ribosomal RNA by ____.
    a. peptide bonds
    b. the codons
    c. the poly-A tail
    d. the mG cap

31. All nucleotides contain the same kind of ____.
    a. ribose sugar
    b. phosphate groups
    c. nucleic acids
    d. pyrimidines

32. During DNA replication, the new strand is assembled from
    a. The leading strand to the lagging strand
    b. the 3’ end of the new strand to the 5’ side
    c. the 5’ end of the new strand to the 3’ side
    d. the replication fork to the RNA primer

33. Which is true in mRNA synthesis?
    a. Proteins fold the RNA after synthesis.
    b. No enzymes are involved.
    c. Only one strand of DNA acts as a template.
    d. Nothing gets added to mRNA afterwards.

34. In what cellular process are introns removed?
    a. Translation
    b. Transcription
    c. RNA synthesis
    d. DNA synthesis

35. The majority of a eukaryotic cell's RNA is found in the…
    a. cytoplasm.
    b. cell membrane.
    c. chromosomes.
    d. non-chromosomal part of the nucleus.

36. If the protein capsule of a bacteriophage is coated with ^{35}S and then infects a bacterial cell, the ^{35}S will be found in…
    a. the bacterial cell and its offspring.
    b. only the bacterial cell.
    c. only the offspring of the bacterial cell.
    d. neither the bacterial cell or its offspring.

37. Which of the following is the best definition of translation?
    a. A strand of mRNA is made complementary to DNA, which can carry the genetic code.
    b. tRNA makes proteins by matching mRNA's code.
    c. Protein chains are assembled when the ribosome connects amino acids.
    d. DNA codes become transfer RNA codes.

38. If the tRNA triplet for aspartic acid is CUA, what is the DNA code for it?
    a. CTA b. GAU
    c. GAT d. ATG

39. The function of the operator gene is to ____.
    a. make the repressor molecule
    b. code for the enzyme that breaks lactose down
    c. determine whether the structural gene is switched on or off
    d. bind to the promoter sequence so that the enzyme is not produced

40. If the inducer is absent…
    a. the cell ceases to transcribe all DNA codes.
    b. the RNA polymerase can bind and reach the structural gene.
    c. the structural gene is shut off so that enzymes aren't made.
    d. the repressor molecule binds to the structural gene so that the enzyme isn't made.

The following three questions are based on the use of radioactive chemicals, which concentrate where stored or used in an organism. Radioactive chemicals can be detected because of their radioactivity.

41. To determine the rate of RNA synthesis, what radioactive substance should be used?
    a. Cytosine
    b. Guanine
    c. Thymine
    d. Uracil

42. To determine the rate of protein synthesis, what radioactive substances should be used?

a. Nucleotides
b. Protein
c. Amino acids
d. Ribosomes

43. To determine the rate of DNA synthesis, what radioactive substance should be used?

a. Cytosine
b. Guanine
c. Thymine
d. Uracil

The following events occurred in a plant cell:

E. An enzyme was manufactured in a ribosome.
F. Cellulose was deposited in a cell wall.
G. Under the influence of DNA, a molecule of RNA was built.
H. Cellulose was formed.
I. A nucleic acid moved from the nucleus to the cytoplasm.

44. These five events are a cause-and-effect sequence. The order in which they occurred was:

a. I-G-H-E-F
b. F-E-H-I-G
c. G-I-E-H-F
d. G-I-E-F-H

Diagram A represents the step-wise production of arginine, an essential amino cid for the pink mold *Neurospora.* Use the diagram to answer the next 4 questions.

KEY: A. A logical hypothesis based on the diagram
B. An illogical hypothesis
C. A hypothesis unrelated to the diagram
D. A restatement of information given in the diagram

45. ____ Enzyme A catalyzes the reaction in which ornithine is formed from the prior substance.

46. ____ If gene B was not present, arginine would be formed directly from ornithine.

47. ____ If gene C was destroyed or missing, the mold would not be able to survive if citrulline was not added to the medium.

48. ____ Different molds have different amino acid requirements.

Use the mRNA codon table to answer the following 2 questions:

49. A portion of the mRNA chain reading UUU-GCU-CGA-UAA
    a. Phenylalanine, Alanine, Arginine, Threonine
    b. Leucine, Alanine, Arginine, Threonine
    c. Threonine, Arginine, Alanine, Leucine
    d. Lysine, Arginine, Alanine, Isoleucine

50. Which of the following blank spots on the table should read "STOP"?
    a. UGU
    b. AUG
    c. UAG
    d. AGU

Name:_____ Date:_____ Block:___

Honors Biology Protein Synthesis Test (100 pts)

Answer Sheet

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____
31. _____
32. _____
33. _____
34. _____
35. _____
36. _____
37. _____
38. _____
39. _____
40. _____
41. _____
42. _____
43. _____
44. _____
45. _____
46. _____
47. _____
48. _____
49. _____
50. _____

Appendix B – "Genetics I" Unit

This appendix contains all lecture notes, overheads, worksheets, labs, and assessments for the Mendelian Genetics units in each level.

Appendix B1 – Honors Genetics I

Genetics I. Mendelian Genetics
Lesson Plan

Day 1:
Review of DNA
Lecture 1 (part): Background about Mendel
Start "Mendel's Garden"* video

Day 2:
Finish "Mendel's Garden" video

Day 3:
Review lecture and video
Finish Lecture 1 – Mendel's principles

Day 4:
"Genotypes-Phenotypes"* worksheet
Lecture 2: Probability
"Probability in Genetics"* worksheet

Day 5 (Long):
Review probability and hw
"Randomness, Chance & Probability"* lab (finish for hw)

Day 6:
Review lab
Quiz #1
Finish Lecture 2: Five steps to solve genetic problems
"Monohybrid crosses"* worksheet (try a few problems for hw)

Day 7:
Lots of practice with monohybrids (more worksheet, finish for hw due day 9)
Start dihybrid crosses
"Dihybrid crosses"* worksheet (do a few problems, the rest are for hw due day 9)

Day 8:
Multiple allele crosses
Lecture 3: Chi Squared

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Day 9:

"Genetics of Maize"* lab

Day 10:

Review lab, lecture, and worksheets
Practice problems

Day 11:

Quiz #2

Day 12:

Lecture: Other types of dominance

Day 13:

"Incomplete dominance"* worksheet
"Incomplete dominance & Chi square"* worksheet (finish for hw)

Day 14:

Review all materials and practice problems

Day 15:

Unit Test

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Honors Bio – **B & E**

Genetics, Lecture 1: Heredity and Mendel's Genetics(Ch. 13)

The big question: "How do traits get passed on??"

Common knowledge: Hereditary info comes from mom and dad…
In Mendel's day:

- Blending Inheritance: mix of the two
- Selective Breeding: you could manipulate characteristics

***What's the problem with all hereditary info blending??.....the whole world would look the same

MENDEL

Wanted to know *how* traits got passed on
Took scientific, mathematical approach to **heredity**
GENETICS = scientific approach to heredity
Mendel's the "Father of Genetics"
Very mathematical, so we'll be using algebra

Mendel did TONS of experiments and took TONS of data…..we'll start with….

The first experiment:

Mendel started with **pure strains**
Pure Strains = all code for the one trait, generation after generation
Needed to know that if two from pure strain bred…all of their **progeny** would be the same…consistency

***Why'd he use peas?.....
Pure strains hard to find with people, easy with peas
Easy and quick to breed peas

He started with just one trait at a time
MONOHYBRID CROSS = crossing plants that only differ by one trait
Traits: all either-or traits

Some terms:
Progeny = offspring
♂ = male
♀ = female

EXPERIMENT 1

♂ Tall Pure Strain X ♀ Short Pure Strain

Progeny: ALL TALL

All Tall is the **phenotype**
PHENOTYPE = what it looks like….how the trait is expressed

***So if all of the tall x short crosses end up tall….how do we still have short ones??
Did the short gene disappear, will it come back? How does a HYBRID work?

The Second experiment

Crossing hybrids, instead of pure strains
Hybrid = mixed genes
Mendel's were crosses of the pure strains, so he knew what sort of hereditary info they could possibly carry
P generation = parental generation, mom and dad
F1 generation = first set of progeny

EXPERIMENT 1
♂ Tall Pure Strain X ♀ Short Pure Strain

F1: ALL TALL

EXPERIMENT 2
F1 Tall X F1 Tall

Progeny: 3 Tall, 1 Short

This isn't blending….it's either 1 or the other!
Short didn't disappear, it didn't change, it got covered up

Mendel's 1st principle: DOMINANCE
DOMINANT TRAIT = the trait that can "cover" the other up
RECESSIVE TRAIT = the trait that gets "covered"

***How should we write this?
T= trait
t = not trait

EXPERIMENT 1
♂ TT X ♀ tt --meiosis→ ♂ T ♀ t

F1: Tt

Mendel's 2nd principle: SEGREGATION
Alleles for a particular trait separate equally during meiosis
Each sex cell gets ONE allele
ALLELE = one form of a gene, or the "brand" of the genes "product"
GENOTYPE = the genetic makeup, the combination of alleles
Heterozygous = two different alleles for one trait
ex. Tt

Homozygous = both alleles are identical for one trait
ex. TT or tt

EXPERIMENT 2

F1 Tt X F1 Tt

Progeny: 3 Tall, 1 Short

Genetics, Lecture 2: The Mathematical Approach (Ch. 13)

PROBABILITY IN GENETICS

PROBABILITY = using math to predict the chance that an event will occur
ex. 4/52 chance of pulling an ace from a deck of cards, a batting average, 1/6 chance of rolling a 2 with dice

- Each event has no effect on another
- Can be more than 1 event in a row
  Ex. a coin landing heads four times in a row
  ½ * ½ * ½ * ½ = 1/16
  ****more problems****

**This works in genetics too!!

1. Determining the chances of getting different combos of alleles from parents
2. Telling if the different between observed traits in offspring and the predicted traits is significant

5 STEPS TO SOLVING GENETIC PROBLEMS

1. ID/Explain the alleles
E = (whatever trait they make up) e = (absence of the trait)

2. Give parents' genotypes
♂ EE x ♀ ee

3. Determine the possible sex cells

♂ EE .	x	♀ ee .
½ E		½ e
½ E		½ e

4. Foil to determine the possible cominbations
(½ E + ½ E) x (½ e + ½ e)
= ¼ Ee + ¼ Ee + ¼ Ee + ¼ Ee
= all Ee

5. Find and explain the genotypic and phenotypic ratios
Genotypic ratio = 1 Ee, all heterozygous
Phenotypic ratio = 1 *dominant trait*, all *dominant trait*

DIHYBRID CROSS = crossing for two traits simultaneously
***Perform a few examples with dihybrid crosses

Honors Bio – **B & E**

Genetics, Lecture 3: Chi Squared (Ch. 13)

X^2 CHI SQUARED TESTS

Let's analyze some of Mendel's data

G = Green Pods g = Yellow pods

G x g P

→ all green (Gg) F1

→ 428 grn + 152 yllw

How "good" are these results? They aren't perfect….can error be explained by chance? Or did we expect the wrong thing? Let's use math to figure it out

428 + 152 = 580 total
Expected green = 580 x ¾ = 435
Expected yellow = 580 x ¼ = 145

Mendel's Group	Expected ratio	Expected # (c)	Observed # (o)	Deviation (d)	d^2	d^2/c
Green	3	435	428	7	7	7/435 = 0.112644
Yellow	1	145	152	-7	7	7/145 = 0.337931

X^2 = deviation value/expected value

$$X^2 = \Sigma \frac{\text{(observed \# - expected \#)}^2}{\text{Expected \#}}$$

$X^2 = \Sigma (d^2/c)$
$= \Sigma (0.112644)\ (0.337931)$
$= \underline{0.450575}$

- Use the **X^2** value to find the range of p
  Use the table to find it
  Degree of freedom = number of groups

- What does the **p** value tell you?
  % chance that blind chance/coincidence could cause this
  % chance that it's more than chance, you have a legitimate factor which makes this deviation **reproducible**
  Ex. p = 0.01 → 1 out of 100 time sit's just chance and ought to be the expected, 99 out of 100 times, it's more than chance and you expected the wrong thing
  A good p value is anything equal to or above 0.05

****perform several more examples****

Name _____

GENOTYPES-PHENOTYPES

Using the following information, complete the table below.

Tall = T	Yellow = Y	Round = R	Spotted = S
Short = t	Green = y	Wrinkled = r	Solid = s

GENOTYPE	PHENOTYPE
TT	_____
Tt	_____
Yy	_____
yy	_____
YySS	_____
RRyy	_____
ttRr	_____
ttyyRR	_____
TTYYSS	_____
TtYySs	_____

_____	short, green pea
_____	homozygous tall, heterozygous yellow pea
_____	heterozygous tall, heterozygous smooth pea
_____	heterozygous yellow, short, solid pea
_____	short, green, homozygous round pea

Bonus:
What are ALL the possible genotypes of a tall, yellow pea?

NAME _____ CLASS _____ DATE _____

CHAPTER
25
ENRICHMENT ACTIVITY
Genetics Problem Solving

Probability in Genetics

Probability is a measure of the likelihood that an event will occur. This likelihood is expressed as a numeric value. When an event is *certain* to occur, its probability equals 1. When an event *cannot* occur, its probability equals 0. When an event *might* occur, its probability is somewhere between 0 and 1 and is expressed as a fraction or decimal, such as ½ or 0.5. Probability can also be expressed as a percentage, such as 50%.

The probability that a particular event will occur is defined as the ratio of "satisfactory" outcomes to all possible outcomes when an "experiment" is performed. For example, what is the probability that the roll of a die will produce a number that is divisible by 3? There are two satisfactory outcomes, the values 3 and 6. There are six possible outcomes, the values 1 through 6. Therefore, the probability that the desired outcomes will occur is ⅔, or ⅓. There are four unsatisfactory outcomes, the values 1, 2, 4, and 5. Thus the probability that the outcome is unsatisfactory (the number showing is *not* divisible by 3) is ⅔, or ⅔. Since it is *certain* that the number showing is either divisible by 3 or not divisible by 3, the sum of these two probabilities (⅓ + ⅔) is equal to 1. Note that for any "experiment," it is always the case that the sum of the probabilities of all possible outcomes (satisfactory and unsatisfactory) will be equal to 1.

Probability can be applied in genetics to predict events such as: (1) the formation of particular gamete genotypes, (2) the formation of particular offspring genotypes by the combining of two gamete genotypes, and (3) the occurrence of multiple, independent events resulting from separate matings. In any cross, it is possible to assign a probability value to each gamete type produced by each parent. Assigning probability values to gamete genotypes enables you to predict offspring genotypes and, therefore, phenotypes, without using the Punnett square.

For example, in an individual with the genotype Tt, there are two possible gamete types that can be produced—those with the T allele and those with the t allele. Therefore, the probability that a gamete from this individual will have the T allele is 1 in 2, or ½. Similarly, the probability that a gamete has the t allele is also ½. Since these two gamete types are the only ones that can form, it makes sense that the sum of their probabilities is 1. In other words, it is certain that any gamete formed by this individual will be either T or t.

In an individual with the genotype TT, there is only one possible gamete type because all gametes will possess the T genotype. Thus, the probability that a gamete from this individual will possess the T allele is ⅓, or simply 1. There is zero probability that a gamete will be of any other genotype. Similarly, the probability that an individual of genotype tt forms a gamete of type t is also 1.

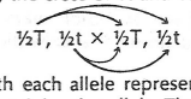
Next, consider a cross where each parent has the Tt genotype. For each parent, the probability of a gamete having the T allele is ½ and the probability of a gamete having the t allele is also ½. The probability of a particular offspring genotype resulting from this cross is found by *multiplying* the probabilities of the gamete genotypes that must combine to form the desired offspring genotype. For example, the probability of a TT offspring genotype forming is the *product* of the probabilities that each parent will donate a T gamete.

NAME _____

CHAPTER 25 ENRICHMENT ACTIVITY **Genetics Problem Solving**

Probability in Genetics (continued)

To illustrate this procedure, the cross of Tt and Tt is expressed as



The fraction associated with each allele represents the probability that the parent donates a gamete containing that allele. The arrows indicate all possible gamete combinations in the offspring. By following the arrows, the possible results of the cross can be listed:

½T × ½T = (½ × ½)TT = ¼TT
½T × ½t = (½ × ½)Tt = ¼Tt
½t × ½T = (½ × ½)Tt = ¼Tt } = ½Tt
½t × ½t = (½ × ½)tt = ¼tt

Thus, by multiplying the gamete probabilities for each possible gamete pair, you can derive the respective offspring probabilities. Note that the two heterozygous crosses can be combined for a total probability of ½. The probability that the offspring is homozygous dominant is ¼, and the probability that the offspring is homozygous recessive is also ¼. The sum of these three probabilities equals 1 as would be expected, because they represent all possible offspring genotypes.

SAMPLE PROBLEM 1

Albinism, the absence of skin pigmentation, is a recessive trait. If one parent carries a single recessive gene, what is the probability that the offspring will be homozygous dominant?

Step 1 Determine the genotypes of the parents. They are PP and Pp.

Step 2 For each allele, define the probability that a parent donates a gamete containing that allele to the offspring. The probability that the homozygous dominant parent donates the P allele is 1. The probability that the heterozygous parent donates the P allele is ½. The probability that the heterozygous parent donates the p allele is also ½.

Step 3 Set up the cross showing all possible gamete combinations.

1P × ½P, ½p

Step 4 Select those gamete combinations that yield the required offspring genotype(s). Multiply the probabilities of the gametes in each pair to obtain the offspring genotype probabilities. A homozygous dominant offspring will have the PP gene pair.

1P × ½P = (1 × ½)PP = ½PP

The probability that the child will be homozygous dominant is ½.

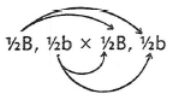
SAMPLE PROBLEM 2

Blue eye color is a recessive trait. If both parents are heterozygous for blue eyes, what is the probability that they will have a child who does not have blue eyes?

Step 1 The parent genotypes are Bb and Bb.

Step 2 The probability that the B allele is donated is ½ for each parent. The probability that the b allele is donated is also ½ for each parent.

Step 3 The cross is



Step 4 A child with nonblue eyes will have the BB or Bb genotype.

$$\tfrac{1}{2}B \times \tfrac{1}{2}B = (\tfrac{1}{2} \times \tfrac{1}{2})BB = \tfrac{1}{4}BB$$
$$\tfrac{1}{2}B \times \tfrac{1}{2}b = (\tfrac{1}{2} \times \tfrac{1}{2})Bb = \tfrac{1}{4}Bb \Big\rangle = \tfrac{1}{2}Bb$$
$$\tfrac{1}{2}b \times \tfrac{1}{2}B = (\tfrac{1}{2} \times \tfrac{1}{2})Bb = \tfrac{1}{4}Bb \Big\rangle$$

Since either resulting genotype is satisfactory, we can *add* their respective probabilities. Then, the probability that the child will not have blue eyes is $\frac{1}{4} + \frac{1}{2} = \frac{3}{4}$.

SAMPLE PROBLEM 3

What is the probability that the parents in Sample Problem 2 will produce two children that do not have blue eyes?

SOLUTION: The probability of identical, multiple, independent events occurring is equal to the *product* of the probabilities for each event.

Since each birth is independent of the other, the outcome of the first birth has no bearing on the outcome of the second birth. We know, then, that the probability that the child will not have blue eyes is $\frac{3}{4}$ in each case. The probability of two successive births with this outcome is

$$\tfrac{3}{4} \times \tfrac{3}{4} = \tfrac{9}{16}$$

Therefore, the probability that the parents have two children who do not have blue eyes is $\frac{9}{16}$.

The following sample problem illustrates the advantage of using probabilities rather than Punnett squares in crosses involving two or more traits.

SAMPLE PROBLEM 4

What is the probability that the offspring of a cross between two heterozygous tall, heterozygous smooth-seeded pea plants will be homozygous tall, heterozygous smooth seeded?

Step 1 Since both parents are heterozygous for tallness and for smooth seed coat, their genotype can be expressed as TtSs.

Step 2 Each parent will produce equal numbers of each of four gamete types—TS, Ts, tS, ts. Thus, each gamete genotype has a probability of $\frac{1}{4}$.

Step 3 All possible offspring genotypes can be obtained by combining each gamete genotype from one parent with each gamete genotype from the other parent. Gamete combinations can be shown as follows:

parent 1	*parent 2*
$\frac{1}{4}$ TS	$\frac{1}{4}$TS
$\frac{1}{4}$ Ts	$\frac{1}{4}$ Ts
$\frac{1}{4}$tS	$\frac{1}{4}$ tS
$\frac{1}{4}$ ts	$\frac{1}{4}$ ts

Step 4 Since offspring only of the TTSs genotype are of interest, select the gamete combinations that will result in this offspring genotype.

parent 1	*parent 2*	
$\frac{1}{4}$ TS ×	$\frac{1}{4}$ Ts = $\frac{1}{16}$ TTSs	$\frac{2}{16} = \frac{1}{8}$ TTSs
$\frac{1}{4}$ Ts ×	$\frac{1}{4}$ TS = $\frac{1}{16}$ TTSs	

Thus the probability of an offspring from this cross being homozygous tall, heterozygous smooth is $\frac{1}{8}$.

RANDOMNESS, CHANCE, PROBABILITY

Information

Can *CHANCE* be reduced to scientific laws? Chance is a name given to a situation in which the causes that affect the outcome are so numerous that we can never hope to pick them out. But even when the causes can never be determined, there are certain mathematical aspects of the situation that we can study and reduce to statements of what to expect. These statements are what we call *PROBABILITIES*. Probabilities explain what is most likely to happen.
RANDOMNESS is another term we apply to the element of chance. It means a choice governed entirely by chance- completely impartial.

Example:

A container is prepared holding 1000 marbles - 500 red and 500 black. The marbles are thoroughly mixed. A blindfolded person reaches in and picks up a marble, the first one he touches and withdraws it. The marble is black, a random choice.

A second marble is withdrawn at random. The first choice involves equal probability of drawing red and black. Did the second? _____

The probability is ever so slightly higher that a red marble will be withdrawn.We can express the probability mathematically- it is the ratio of 500 to 499 or 500 out of 999, which is slightly greater than 1/2.

In heredity, we are concerned with the occurrence, every time an egg is fertilized, of the probability that a particular gene or chromosome will be passed on through the egg or through the sperm, to the offspring.

In genetics, we are faced with the probability that a certain allelle will go into the egg, together with the probability that it will go into the sperm, together with the probability that these will combine at fertilization. The following laboratory demonstrates the probabilities, by using a model.

EXPERIMENTAL DESIGN

Part A The Product Rule

1. Examine two dice. How many sides does each one have? _____
2. What is the chance with one die that a particular number will come up ?_____
3. How many even numbers on a die? _____
4. What is the probability that any even number will come up? _____
5. What is the probability that an odd number will come up? _____

Prepare a score sheet with two columns, headed ODD and EVEN. After every tenth throw, draw a line across the tally sheet, and total odds and evens. Make a total of 100 throws, and find the grand total.

6. How do the results of each group of 10 throws compare with the expected 1/2 odd : 1/2 even?

7. How does the total for 100 throws compare to 1/2 odd : 1/2 even?

The difference between what you obtain and what you expect is known as *DEVIATION*. For example, in each lot of 10 throws, you expect by chance to get five odd and five even. Suppose you obtained, in one lot, six odd and four even. The deviation from expectation is then one for the odd and one for the even, or a total of two, which is 20 percent of the 10 throws.

8. Calculate the deviations for each of the 10 groups, as well as for the total of 100, expressing them as percentages. Are the deviations for the smaller groups of 10 throws greater or less, as a rule, than the deviation for the total of 100 throws?

9. How does this demonstrate the importance of the size of the sample in all studies involving probabilities?

10. All the teams in the class should now pool their trials and the class deviation should be calculated as a percentage.
What is the class deviation? _____

11. How does this additional increase in the size of the sample influence the deviation from the expected ratio?

12. On the basis of the comparisons, how large should a sample group be?

Each group should now throw 2 different dice at once, letting one die represent the egg and the other the sperm. The combination that turns up will then represent the purely random probability of the odd and even eggs uniting with odd or even sperms in fertilization. To distinquish the die that represents the egg from that which represents the sperm, use dies of different color or size.

There will be 4 possible combinations of the odd and even numbers on the 2 dice. Prepare a score sheet with 4 columns, headed : BOTH EVEN - EGG EVEN /SPERM ODD - EGG ODD/ SPERM EVEN - BOTH ODD. Make a total of 40 throws.

13. What do you find to be the frequency of each of the combinations?

14. Why are the frequencies so nearly equal to each other?

15. If the results for the entire class are totaled, how do they compare with the expectation?

16. What common fraction best expresses the probability of any one of the 4 combinations?_____

The probability of a combination of independent events is the product of their separate probabilities, PRODUCT RULE OF PROBABILITY. The product rule of probability allows the calculation of probabilities by simple algebraic mulitplication.

Use E as a symbol for even and O as a symbol for odd. You can then express the probabilities as :

EGGS (1/2 E + 1/2 O)

X

SPERMS (1/2 E + 1/2 O)

Assume that E^2 is EE and O^2 is OO and that EO and OE are the same.

17. What is the total product of the above equation?_____

18. The resulting ratio of the 3 classes corresponds to what ratio found by Mendel?

19. When should this ratio be expected ? (What must the genotypes of the 2 parents be for this ratio to occur?)

20. Suppose that E was dominant to O, what would the ratio of even combinations to odd ones become?

RANDOMNESS, CHANCE and PROBABILITY

PERIOD _____ GROUP _____

DATE _____ _____

_____

GRADE _____ _____

PART A.

1._____

2._____

3._____

4._____

5._____

6._____

7._____

8._____

9._____

10._____

11._____

12._____

13._____

14._____

15._____

16._____

17._____

18._____

19._____

20._____

Name:_____ Date:_____ Block:_____

Honors Biology Genetics Quiz #1 (15 pts)

1. Prior to Mendel's research, most people believed in _____ inheritance.

2. Mendel wanted to start with the basics of hybridization, so his first crosses were between _____ strains.

3. A _____ is when you cross organisms to breed for one trait, and a _____ is when you cross organisms to breed for two traits.

4. Explain the difference between a genotype and a phenotype, and provide an example of each.

5. What is the difference between being heterozygous and homozygous?

6. What is Mendel's Principle of Dominance, and how is it related to the phenotype?

7. What is Mendel's Principle of Segregation, and how is it related to the genotype?

MONOHYBRID CROSSES

NAME_____

1. A heterozygous tall pea plant is crossed with a homozygous short pea plant.

   What % of the offspring show the recessive short trait? _____

   What % of the offspring show the dominant trait? _____

2. Wrinkled seeds are dominant to round seeds in pea plants. Which of the following crosses produce the most round seeds.

Wrinkled x Wrinkled	Round x Wrinkled	Round x Wrinkled
Ww x Ww	ww x WW	ww x Ww

3. In peas, the gene for wrinkled seeds (W) is dominant to round seeds (w). A heterozygous wrinkled pea is crossed with a round seed pea.

   a) Complete the Punnett Square

   b. What is the genotype of the parent wrinkled seed pea? _____

   What is the genotype of the parent round seed pea? _____

   c. What are the phenotypes of the offspring? _____

   d. What is the phenotype ratio? _____

4. In tomatoes, round fruit (O) is dominant to oblong fruit (o). Write the genotypes of the following:

   a) a plant homozygous round fruited _____

   b) a plant with oblong fruit _____

   Give the phenotype ratios of the following crosses:

a) A homozygous round x heterozygous round _____

b) A heterozygous round x heterozygous round _____

c) A heterozygous round x oblong _____

d) oblong x oblong _____

5. In cattle, the hornless condition (H) is dominant to the horned condition (h)

   a) A horned bull is mated to a hornless cow that is heterozygous for the condition. What kinds of offspring are to be expected and in what ratio?

   _____

   b) A heterozygous hornless cow is mated to a heterozygous hornless bull. What is the chance the calves will be horned? _____

6. Human eye color is inherited as if brown eyes (B) is a dominant gene and blue eyes (b) to a recessive gene. A man with blue eyes marries a brown eyed woman whose mother had blue eyes. What proportion of their children would be expected to have blue eyes?

7. In squash, white color (W) is a dominant gene and yellow color (w) is a recessive gene. A hetereozygous white squash plant is crossed with a yellow squash plant. What phenotype and genotype ratios would you expect from the offspring?

8. A purple flowered pea plant is crossed with a white flowered pea plant. All the F1 plants produced purple flowers. When the F1 plants are allowed to self-pollinate, 401 of the F2's have purple flowers and 131 have white flowers. What are the genotypes of the parental and the F1 generation plants?

Ans._____

9. In tomatoes, red fruit color is dominant to yellow. Suppose a tomato plant homozygous for red is crossed with one homozygous for yellow. Determine the appearance of a) the F1; b) the F2, in a cross between 2 F1's; c) the offspring in a cross of the F1 back to the red parent; d) the offspring of a cross of an F1 back to the yellow.parent.

Ans. a._____

b._____

c._____

d._____

10. A red-fruited tomato plant, when crossed with a yellow-fruited one, produces progeny about half of which are red-fruited and half of which are yellow-fruited. What are the genotypes of the parents?

Ans._____

11. In guinea pigs rough coat (R) is dominant over smooth coat (r). A rough-coated guinea pig is bred to a smooth one, giving eight rough and seven smooth progeny in the F1. a) What are the genotypes of the parents and their offspring? b) If one of the rough F1 animals is mated to its rough parent, what progeny would you expect?

Ans. a._____

b._____

12. In cattle the polled (hornless) condition (P) is dominant over the horned (p) phenotype. A particular polled bull is bred to three cows. With cow A which is horned, a horned calf is produced; with a polled cow B a horned calf is produced; and with horned cow C a polled calf is produced. a) What are the genotypes of the bull, b) and the three cows, and c) what phenotypic ratios do you expect in the offspring of these three matings?

Ans. a._____

b.A_____ B_____ C_____

c.A_____ B_____ C_____

13. Two black female mice are crossed with the same brown male. In a number of litters female X produced 9 blacks and 7 browns and female Y produced 14 blacks. a) What is the mode of inheritance of black and brown coat color in mice? b) What are the genotypes of the parents?

Ans. a._____

b._____

14. In cocker spaniels, solid coat color is dominant over spotted coat. Suppose a pure-breeding solid-colored dog is crossed with a spotted, and the F1 dogs are interbred. a) What is the probability that the first dog born will have a spotted coat? b) What is the probability that if four puppies are born, all of them will have a solid coat?

Ans. a._____

b._____

NAME_____

DIHYBRID CROSSES

1. A heterozygous tall and smooth pea is crossed with another heterozygou tall and smooth pea.

   What % of the offspring are tall and smooth? _____

   What % of the offspring are short and smooth? _____

   What % of the offspring are short and wrinkled? _____

2. Black hair color (B) is dominant to white hair color (b) in guinea pigs and long hair (L) is dominant to short hair (l). A male guinea pig with heterozygous long, white hair is crossed with a homozygous black, short haired female.

   a) male's genotype _____

      female's genotype _____

   b) Complete the cross

   c. What are the phenotypes of the offspring? _____ _____

   d. What is the phenotype ratio? _____

3. In guinea pigs, short hair (L) is dominant to long (l). Black fur (A) is dominant to albino (a). A female from a strain which is pure breeding for black fur and short hair

is mated to a male from a strain pure breeding for the albino condition and long hair

a) What will be the phenotypes of the F1 ? _____

If members of the F 1 are mated among themselves:

b) What % of the offspring can be expected to be homozygous for both traits?

_____

c) Give the genotypes and phenotypes of these homozygotes?

_____

4. In watermelons, the genes for green color (G) and short shape (S) are dominant over the genes for striped color (g) and long shape (s). A plant with long striped fruit is crossed with a plant hetereozygous for both genes. What phenotypes ratios would be produced?

5. In peas, the gene for tall (T) is dominant over the gene for short (t) and the gene for smooth (S) is domiant over the gene for wrinkled (s). Calculate the phenotype ratios for each of the following crosses.

a) TtSs x TtSs
b) Ttss x ttss Which cross produces the most tall smooth?
c) ttSs x Ttss
d) TTss x ttSS Which cross produces the most short wrinkled?

6. In watermelons, the genes for green color (G) and short shape (S) are dominant over the genes for striped color (g) and long shape (s). A plant with long striped fruit is crossed with a plant heterozygous for both genes. What phenotype ratios would be produced?

7. In peas, the gene for tall (T) is dominant over the gene for short (t) and the gene for smooth (S) is dominant over the gene for wrinkled (s). Calculate the phenotype ratios for each of the following crosses.

   A. TtSs x TtSs

   B. Ttss x ttss

   C. ttSs x Ttss

   D. TTss x ttSS

8. In Jimsonweed purple flower (P) is dominant to white (p), and spiny pods (S) are dominant to smooth (s). In a cross between Jimsonweed homozygous for white flowers and spiny pods and one homozygous for purple flowers an smooth pods, determine the phenotype of (a) the F1; (b) the F2; (c) the progeny of a cross of the F1 back to the white, spiny parent; (d) the progeny of a cross of the F1 back to the purple, smooth parent.

   Ans. a._____

   b._____

   c._____

   d._____

9. What progeny do you expect to find from the following Jimsonweed crosses?

   a. PPss x ppSS

   b. PpSS x ppss

   c. PpSs x PpSS

   d. PpSs x PpSs

   e. PpSs x Ppss

   f. PpSs x ppss

Ans. a._____

b._____

c._____

d._____

e._____

f._____

10. In summer squash white fruit (W) is dominant over yellow (w), and disk-shaped fruit (D) is dominant over sphere-shaped fruit (d). In the following problems the appearances of the parents and their progeny are given. Determine the genotypes of the parents in each case.

a) White, disk x yellow, sphere gives 1/2 white, disk and 1/2 white, sphere
b) White, sphere x white, sphere gives 3/4 white, sphereand 1/4 yellow. sphere
c) Yellow, disk x white sphere gives all white, disk progeny
d) White, disk x yellow, sphere gives 1/4 white, disk, 1/4 white, sphere, 1/4 yellow, disk, and 1/4 yellow, sphere
e) White, disk x white, sphere gives 3/8 white, disk, 3/8 white, sphere, 1/8 yellow, disk, and 1/8 yellow, sphere

Ans. a._____

b._____

c._____

d._____

e._____

11. In garden peas tall stem (T) is dominant over short stem (t), green pods (G) are dominant over yellow pods (g), and smooth seeds (S) are dominant over wrinkled seeds (s). Suppose a homozygous short, green, wrinkled pea plant is crossed with a homozygous tall, yellow, smooth one.

a) What will be the appearance of the F1?
b) What will be the appearance of the F2, if the F1's are allowed to interbreed?
c) What will be the appearance of the offspring of a cross of the F1 back to its short, green, wrinkled parent?

d) What will be the appearance of the offspring of a cross of the F1 back to its tall, yellow, smooth parent?

Ans. a._____

b._____

c._____

d._____

12. In chickens the white plumage (W) of the leghorn breed is dominant over colored plumage (w), feathered shanks (F) are dominant over clean shanks (f). and pea comb (P) is dominant over single comb (p). Each of the gene pairs segregates independently. If a homozygous white, feathered, pea-combed chicken is crossed with a homozygous colored, clean, single-comb chicken and the F1's are allowed to interbreed, what proportion of the white, feathered, pea-combed birds in the F2 will produce only white, feathered, pea-combed progeny if mated to colored, clean-shanked, single-combed birds?

Ans._____

THE GENETICS OF MAIZE

Information

In the genetic corn that you will examine the various genes express themselves by producing variously colored and shaped kernels. You will determine the number of characteristics involved and which genes are dominant and which are recessive by counting the variously colored and shaped kernels in the ear. Carefully record your answers. All of these ears are the second filial (F2) generation.

OBSERVATIONS

1. List the various phenotypes by color and shape of the kernels on the maize. (4)

_____ _____

_____ _____

2. Count the kernels of each phenotype in the rows of corn and record them by phenotype below

PHENOTYPE

_____ _____ _____ _____

Totals _____ _____ _____ _____

3. What is the total number of kernels? _____

4. What is the percentage of each phenotype ?

_____ _____ _____ _____

5. What is the ratio of purple to white ? _____

6. Which is dominant ? _____ Which is recessive? _____

7. What is the ratio of smooth to wrinkled ?_____

8. Which is dominant? _____ Which is recessive? _____

9. What is the ratio of the 4 phenotypes ? _____

11. What were the genotypes and phenotypes of the parents that produced this ear?

_____ _____

CHI SQUARE TEST

Perform the chi-square test of reliability to see if your hypothesis about what kind of mating produced these kernels is statistically validated by the data that you have collected.

HINT: Re-read the Chi Square Information Sheet

You perform this test by determining:

a. the deviation between what you expected and what you observed for each phenotype

b. squaring the result

c. dividing it by the expected for that phenotype.

d. add all of these together to get a chi-square value.

Use the chi-square chart:

a. find the degrees of freedom (d.f.)
(number of phenotypes , minus one)

b. reading across the chart until you find the value in the chart nearest to your chi-square value.

c. read up the chart to find your probability value (p).

$$\frac{(\text{OBSERVED} - \text{EXPECTED})^2}{\text{EXPECTED}} = X2$$

12. What is your (p) value ? _____

13. What does this mean ?

Lab: The genetics of Maize
Answer Sheet

Name _____
Name _____
Name _____
Period _____
Date _____
Group _____

Read the information section at the beginning of the lab in the lab book. Observe the maize kernels (each kernel is a different offspring from the same two parents). Determine the different phenotypes exhibited by the kernals and write them below:
Under each phenotype, write the number of that phenotype that you observed (#2a) and under that write the total number of that phenotype observed by the class (#2b).

1. _____ _____ _____ _____

2a. _____ _____ _____ _____

2b. _____ _____ _____ _____

3a. What is the total number of kernels observed by your group? _____

3b. What is the total number of kernels observed by the entire class? _____

4. What is the total percentage of each phenotype (use the entire class data):

Phenotypes: _____ _____ _____ _____

Percentage: _____ _____ _____ _____

5. What is the ratio of purple to white? _____

6. Which color is dominant over the other? _____

7. What is the ratio of smooth to wrinkled? _____

8. Which trait is dominant over the other? _____

9. What is the simplified ratio of the 4 phenotypes?

_____

10. What were the genotypes of the parents that produced this ear?

_____

Chi Square Test (Show all calculations in the space at the bottom of this sheet or on the back of this sheet).

12. What is your (p) value? _____

13. What does this mean? _____

_____

CHI-SQUARE

The Chi-Square test can be used to find if the observed results of an experiment are in agreement with the expected results of the hypothesis, or if some other factor(s) not accounted for in the hypothesis could be influencing the results other than chance alone.

The formula used:

$$\chi^2 = \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

The reliability of the Chi-Square results can be determined by the following chart:

d.f.	p = 0.9	p = 0.5	p = 0.2	p = 0.05	p = 0.01	p = 0.001
1.	.0158	.455	1.642	3.841	6.635	10.827
2.	.211	1.386	3.219	5.991	9.210	13.815
3.	.584	2.366	4.642	7.815	11.345	16.268
4.	1.064	3.367	5.989	9.488	13.277	18.465
5.	1.610	4.351	7.289	10.070	15.086	20.517
6.	2.204	5.348	8.588	12.592	16.812	22.457
7.	2.833	6.346	9.803	14.067	18.475	24.322
8.	3.490	7.344	11.303	15.507	20.098	26.125
9.	4.168	8.343	12.242	16.919	21.666	27.877
10.	4.865	9.342	13.442	18.367	23.289	29.568

d.f. is Degrees of Freedom which is the number of attributes or cases being studied, less one.

p is probability. p = 0.9 means there are 90 times per hundred that chance alone would produce the observed deviation between the expected and observed results.

Name:_____ Date:_____ Block:_____

Honors Biology Genetics Quiz #2 (25 pts)
***Be sure to show all of your work!

1. In mice, the allele for black fur is dominant over the allele which causes the albino condition. A black male mouse is bred to three female mice. The resulting offspring from black Female Mouse #1 is albino. The offspring from albino Female #2 is an albino mouse. Female Mouse #3, who is albino, gives birth to a black mouse. A) What is the male mouse's genotype? B) What are each of the female mice's genotypes? C) What phenotypic ratios would you expect in the offspring of these crosses? (7 pts.)

A) _____

B) 1._____ 2._____ 3._____

C) 1._____ 2._____ 3._____

2. In humans, the allele for tongue-rolling is dominant to the non-rolling. The allele for hair growing on the middle portion of the finger is also dominant to the non-hairy allele. Bob is a hairy-knuckled tongue-roller. Bob's father was also a hairy-knuckled tongue-roller. Bob's mother had hairless fingers and, sadly, could not roll her tongue. Bob's wife is a hairless tongue-roller (who's mother could not roll her tongue either). A) What was his father's genotype? B) What was his mother's genotype? C) What is Bob's genotype? D) What phenotypic ratio can Bob and his wife expect in their children? (4 pts)

A) _____ B) _____ C) _____

D) _____

3. In humans, having a widow's peak (W) is dominant to having a continuous hairline (w). Free-dangling earlobes (E) are dominant to attached earlobes (e).

A man who is heterozygous for the widow's peak and earlobes and a woman who is heterozygous for the widow's peak but homozygous dominant for the earlobes have children. What would the A) genotypic and B) phenotypic ratios of the progeny be? (4 pts)

A) _____

B) _____

4. In watermelons, the genes for green color (G) and short shape (S) are dominant over the genes for Striped color (g) and long shape (s). In the following problems, the appearances of the parents and their progeny are given. Determine the genotypes of the parents in each cross. (10 pts)

A) Green, short x striped, long yields 1/2 green, short and 1/2 green, long.
B) Green, long x green, long yields 3/4 greene, long and 1/4 striped, long.
C) Striped, short x green, long yields all green, short progeny
D) Green, short x striped, long yields 1/4 green, short, 1/4 green, long, 1/4 striped, short, and 1/4 striped, long.
E) Green, short x green, long yields 3/8 green, short, 3/8 green, long, 1/8 striped, short, and 1/8 striped, long.

A) _____

B) _____

C) _____

D) _____

E) _____

INCOMPLETE DOMINANCE

NAME_____

MONOHYBRID

1. In cattle, the alleles for red coat (R) and white coat (W) behave as codominants. Both red and white hair color are produced so that the heterozygous is intermediate or roan colored.

a) Give the phenotypic and genotypic ratios to be expected among the offspring from a cross of two roan animals.

b) What are the expected genotypic and phenotypic ratios from a cross of a roan animal and a white one?

2. Which of the following crosses produce the most pink roses?

Pink x Pink Pink x White Pink x Red

3. In cattle coat color varies between red, roan and white. What offspring would be expected from a mating of a :

A. roan cow and roan bull
B. roan cow and white bull
C. red cow and white bull

4. In certain strains of chicken, matings between a black chicken and a white chicken produce offspring all of which have a distinct blue color. If two blue chickens are crossed, what will the phenotype ratio of the offspring be?

5. In short horn cattle, coat color is an incompletely dominant trait. Cattle can be:

pure red = rr pure white = ww roan = rw

a. Complete these crosses.

RED X WHITE ROAN X WHITE ROAN X ROAN

b. Which produces the most white offspring? _____

red offspring? _____

roan offspring ? _____

DIHYBRID

6. In certain breeds of chickens, the factor (B) is responsible for the production of black feathers and its allele (W) produces feathers that are basically white. The heterozygote is blue-feathered. Another trait (S) produces straight feathers, whereas its allele (F) results in frizzled feathers. The heterozygote is mildly frizzled.

Give the phenotype ratios for the following crosses:

a) a black, frizzled hen X a white, straight rooster

b) a white, frizzled hen X a blue, straight rooster

c) a blue, mildly frizzled hen X a white, frizzled rooster

d) a blue, mildly frizzled hen X a blue, mildly, frizzled rooster

7. Coat color and horn length are incompletely dominant traits in cattle. A roan bull with medium length horns was mated with a red cow with short horns

rr = red
rw = roan
ww = white

ll = long
ls = medium
ss = short

a) Bull's genotype? _____

b) Cow's genotype ? _____

c. What are the phenotype's of the offspring? _____ _____

_____ _____

d. What is the phenotype ratio? _____

8. In certain breeds of chickens, the factor (B) is responsible for the production of black feathers and its allele (W) produces feathers that are basically white. The heterozygote is blue-feathered. Another trait (S) produces straight feathers, whereas its allele (F) results in frizzled feathers. The heterozygote is mildly frizzled.

Which cross produces the most: blue, straight chickens? _____

black, straight chickens? _____

a) a black, mildly frizzled hen x a blue, straight rooster

b) a blue, mildly frizzled hen x a blue, mildly, frizzled rooster

Name:_____ Date:_____ Block:___

Honors Biology Genetics (Ch 13.1-7) Test (100 pts)

1. The genetic makeup of an organism for a particular trait is its
   A. genotype. C. dominance.
   B. phenotype. D. allele.

2. The appearance of an organism is its
   A. allele. C. phenotype.
   B. dominance. D. genotype.

3. Genes are sequences of nucleotides that may code for
   A. proteins only.
   B. enzymes only.
   C. messenger RNA only.
   D. polypeptides, proteins, tRNA, and mRNA.

4. A trait that is not visible in the F_1 generation but reappears unchanged in the F_2 generation is
   A. recessive. C. monohybrid.
   B. dominant. D. heterozygous.

5. Mendel's principle of segregation refers to the
   A. separation of alleles for a particular trait during gamete formation.
   B. independent behavior of alleles for different traits during gamete formation.
   C. difference of alleles for a trait in a heterozygous genotype.
   D. expression of phenotype in an individual.

6. What is the chance, if a couple has two children, that they will have one boy and one girl?
   A. ½ C. 1/8
   B. ¼ D. 1/1

7. The genetic makeup of an organism for a particular trait
   A. is visible in its phenotype.
   B. changes during mitosis.
   C. depends on whether the allele is dominant.
   D. is determined by the genotype.

8. A family has seven children, one son and six daughters. What is the chance that the eighth child will be a daughter?
   A. 1/12 C. 1/8
   B. 1/128 D. 1/2

9. Three quarters of the progeny from many experimental crosses showed only the dominant trait. The parents were
   A. both pure dominant.
   B. both heterozygous.
   C. one pure dominant, one recessive.

10. Mendel discovered principles of inheritance because he

A. observed simultaneously all of the characteristics in which parents differed.
B. believed that hereditary characteristics of two individuals blended in the offspring.
C. ignored all characteristics except a few markedly contrasting ones that he studied carefully.
D. studied only the offspring obtained from a single mating.

11. An individual has the genotype Dd. The reproductive cells it produces will be

A. ½ DD and ½ Dd.
B. ¾ DD and ¼ Dd.
C. ½ D and ½ d.
D. ¾ D and ¼ d.

12. Which step in meiosis corresponds to Mendel's principle of segregation?

A. condensation of chromatids into chromosomes.
B. replication of chromatids.
C. separation of sister chromatids.
D. separation of homologous chromosomes.

13. What is the probability of two fours showing up if a *pair* of dice is rolled?

A. ½
B. ¼
C. 0
D. 10/12

14. What characteristic of garden peas made them ideal test organisms for Mendel's genetic studies?

A. Garden peas can self-pollinating.
B. They express "either-or" traits.
C. There are only a few genetic features to be studied.
D. A & B

15. A cross is made between Aa and Aa. What is the probability that an offspring will have the genotype aa?

A. 1/16
B. 1/8
C. 1/4
D. 1/2

For the next five questions, tell how many different kinds of gametes (with respect to the traits listed) each of the individuals shown below could produce.

A. 1
B. 2
C. 4
D. 8

16. Bb
17. BBFF
18. BbFf
19. bbffMm
20. bbffmm

21. A represents the gene for a dominant characteristic and a is its recessive allele. If Aa mates with aa,

A. all offspring will be of the dominant phenotype.
B. all offspring will be of the recessive phenotype.
C. 50% of the offspring will be of the recessive phenotype.
D. 75% of the offspring will be of the dominant phenotype.

22. In the fruit fly, gray body G is dominant over black body g. Two gray flies mate and produce 49 blacks and 158 grays. The parents were probably

A. BB x BB.
B. Bb x Bb.
C. BB x Bb.
D. Bb x bb.

23. A mother has Type-A blood. The father had Type-B blood. Their child has Type-O blood. It is clear that

A. a mutation had occurred.
B. the parents were both heterozygous.
C. the father was homozygous B.
D. the other was homozygous A.

24. For the next five questions, use the key below. Assume that B = dominant, b = recessive.

Key: A. All offspring will show dominant trait.
B. All offspring will show recessive trait.
C. About 50% of offspring will show recessive trait.
D. About 75% of offspring will show dominant trait.

25. What will be the result of the following crosses?

Bb x bb
BB x bb
bb x bb

A plant that is heterozygous for tallness and heterozygous for red flowers (red and tall are dominant) self-fertilizes and has several hundred offspring. Use this information to answer the next two questions.

26. What is the probability that the offspring will be short and red?

A. 1/16
B. 3/16
C. 4/16
D. 9/16

27. In cattle, heterozygotes who carry both the allele for red coat (R) and white coat (W) express an intermediate phenotype (roan). If a red bull is cross with a roan cow, what portion of the progeny will be red?

A. 1/8
B. 1/4
C. 1/2
D. 1/1

28. What is the probability that the progeny will be tall and white?

A. 1/16
B. 3/16
C. 4/16
D. 9/16

29. What is the mode of inheritance in #28?

A. Complete Dominance
B. Codominance
C. Incomplete dominance
D. Dihybrid

Use the following table of crosses and the Key to answer the next five questions.

P Cross	F_1 Plants	F_2 Plants
Round seeds x wrinkled seeds	All offspring round	5,474 round 1,850 wrinkled

KEY: A. P plants
B. F_1 Plants
C. F_2 Plants

30. From the individuals of which generation did Mendel develop the idea of dominance?

31. Which generation is considered true-breeding?

32. From which generation did Mendel develop the idea of the recessive trait?

33. Which generation is 100% heterozygotes?

34. Which generation includes no heterozygotes?

In humans a widow's peak (W) is dominant to a continuous hairline (w), and dangling earlobes (D) are dominant to attached earlobes (d). What are the genotypes of the parents in the next three crosses?

35. Widow's peak, dangling x continuous, attached yields ½ widow's, dangling and ½ widow's, attached

A. Wwdd x Wwdd
B. WWDd x wwdd
C. wwDD x WWdd
D. WwDd x wwdd

36. Continuous, dangling x widow's, attached yields all widow's, dangling progeny.

A. Wwdd x Wwdd
B. WWDd x wwdd
C. wwDD x WWdd
D. WwDd x wwdd

37. Widow's, attached x widow's, attached yields ¾ widow's, attached and ¼ continuous, attached.

A. Wwdd x Wwdd
B. WWDd x wwdd
C. wwDD x WWdd
D. WwDd x wwdd

38. What types of gametes can be produced by a pea plant with green pods and round seeds (genotype GGRr)?

A. GG, Rr
B. G, R, r
C. GR, Gr, gR, gr
D. GR, Gr

One hundred seeds are produced by cross-pollinating two green plants. Half of these seeds are grown in the dark at 35°C, the other half in the light at 35°C. At the end of the experiment, it is observed that all seedling growing in the dark are white; of the seedlings growing in the light, 78% are green and the rest are white. (Use this information to answer the next three questions)

39. When grown in the dark, all the seedlings are white because
    A. they are all homozygous for white color.
    B. of the environment in which they are grown.
    C. they are heterozygous for green color.
    D. a mutation has occurred.

40. Which variable is being investigates in this experiment?
    A. light
    B. chlorophyll
    C. temperature
    D. dominance of albinism

41. The two parents of the offspring were
    A. both homozygous green.
    B. both heterozygous green.
    C. homozygous green and homozygous white.
    D. homozygous green and heterozygous green.

42. A coin is tossed three times. The probability that it will land heads up all three times is
    A. 1/2
    B. 1/4
    C. 1/8
    D. 1/16

43. Two coins are tossed together 40 times. Approximately how many times should both land tails up?
    A. 10
    B. 20
    C. 25
    D. 30

44. Why did Mendel start with pure-breeding strains?
    A. That way the incomplete dominance wouldn't interfere with the experiment.
    B. It was the only way he could be sure of what the parents' genetic material was.
    C. He needed to cross for either-or traits.
    D. He didn't start with pure-breeding strains, he used hybrids.

45. If a boy's blood type is AB+, which of the following can his parents *not* be?
    A. AB+- x AO+-
    B. AB-- x AB ++
    C. AO++ x BO ++
    D. AB -- x AB –

Appendix B2 – AE Genetics I

Genetics I. Mendelian Genetics
Lesson Plan

Day 1:
Lecture: Background about Mendel
Start "Mendel's Garden"* video

Day 2:
Finish "Mendel's Garden" video

Day 3:
Review video
Lecture: Start Mendel's Principles
"Words to Know" sheet
"Mendelian Genetics"* worksheet (hw)

Day 4:
Lecture: Mendel's Principles, Punnet Squares
"Genotypes-Phenotypes"* worksheet
"Genetics Practice Problems"* worksheet

Day 5 (long):
"Genetics With a Smile"* lab

Day 6:
Review lab
"Expected and Observed Results"* worksheet
Selected problems from "Monohybrids"* worksheet

Day 7:
Lots of practice with monohybrids
Quiz

Day 8:
Lecture: Dihybrid crosses
"Crosses Involving Two Traits"* worksheet
Selected problems from "Dihybrid crosses"* worksheet

Day 9:
Review materials
Review Game!

Day 10:
Unit Test

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Mendelian Genetics Lecture Notes (Ch 8)

Why do we look like we do? What makes us who we are? Inheritance! We've always had an idea that we inherit traits from our parents…

Genetics: the study of inheritance

- **Genes:** units of DNA that code for how a trait is expressed

Who founded the science of genetics?

MENDEL - "*The father of genetics"*

- 1822-1884, published in 1866
- German monk, well educated: Math, biology, botany
- Raised on a farm, curious about how breeding worked
- Wanted to study the **mechanism of inheritance**

Before Mendel:

Blending Inheritance: parents' traits mix equally in offspring

Mendel's approach: pea plants

- They didn't always blend
- Simple ratios of offspring

- Why peas?.....easy, controlled, small, self-fertilizing….
- Either-Or traits
- **Purebreads** (vs hybrids) for parents
- Controlled experiments
- MATH

The First Experiment

- P, female/male, F1, F2, ♀♂…
- Tall x Short
  → All Tall x
  → 3 Tall, 1 Short
- NOT blending…because if the traits had mixed, you wouldn't see them later on…..one was just COVERED

- **Dominant Trait:** can cover other traits
- **Recessive Trait:** can be covered by other trait
- **Alleles:** different versions of the same trait

The numbers in the F2 generation allowed him to understand alleles…..

- **2 Alleles** in every individual for most traits
- **T = trait**
  t = not trait

- **Homozygous:** same two alleles, (ex. TT or tt)
- **Heterozygous:** two different alleles (Tt)

- **Genotype:** the alleles an individual carries
- **Phenotype:** how the trait is expressed
  - in homozygous : dom or rec
  - in heterozygous: only dom

Mendel knew you were getting something from each parent….he knew the alleles must separate when gametes were formed (new concept)

- P ♂ TT x ♀ tt

  Tt Tt Tt Tt

- **Principle of Segregation:**
  - Parents' chromosomes separate equally during meiosis
  - Each parent is giving one allele, so that offspring gets two total

There's an easier way to organize this…developed by a scientist named Punnett

SQUARES

Notice that it's a matter of chance how they are organized? Mendel did too, and it was very important in being able to predict F1/F2 generations

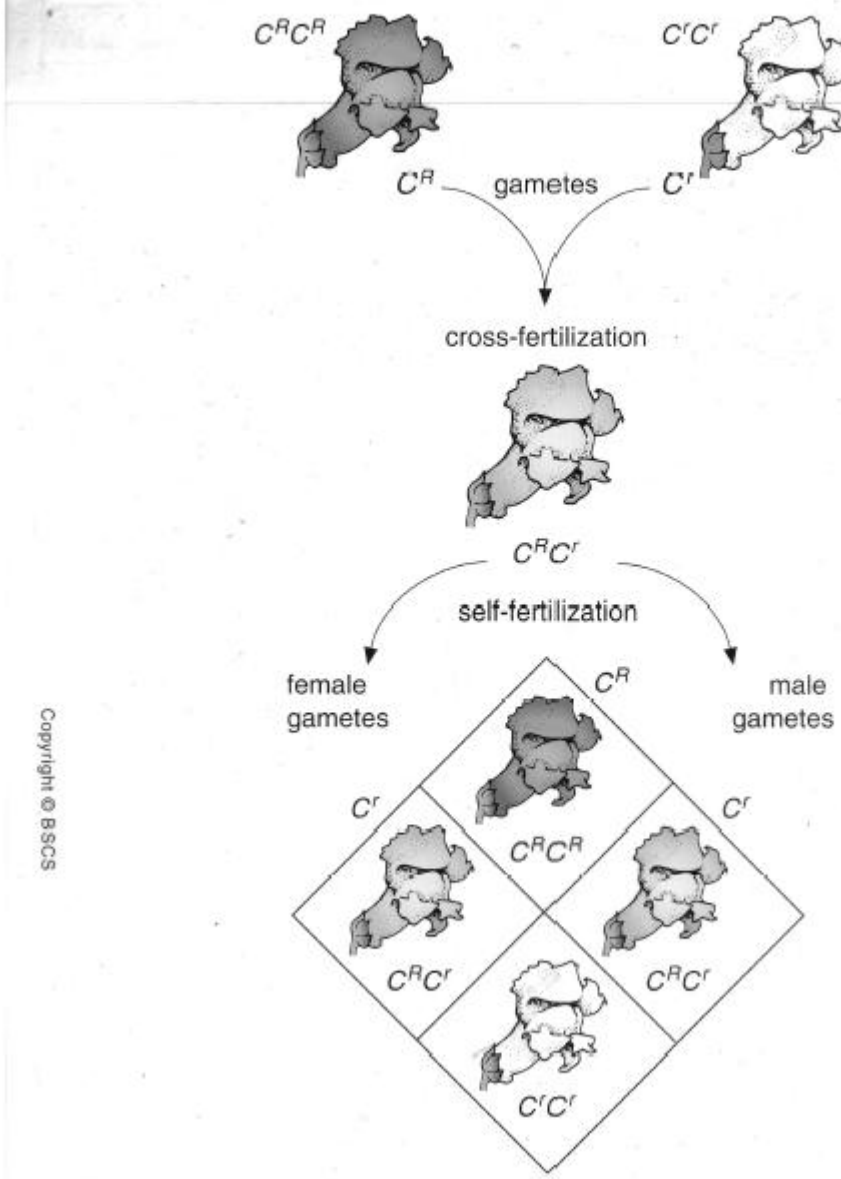
- **Principle of Independent Assortment**
  Parents' chromosomes combine at random in F1
  Each allele has an equal chance of getting passed on
  - -like heads/tails on coin, odds or evens in dice
  - 50/50

LOTS OF CROSSES
WORKSHEETS WITH READING & CROSSES

Incomplete Dominance

Chapter 13

Codominance of Flower Color 28



So far we've only covered crosses for one trait…how about for two?

Monohybrid crosses: crosses breeding for one trait

Dihybrid cross: cross breading for two traits

MORE CROSSES/PROBLEMS/WKSHTS

There are also other means/modes of inheritance that Mendel didn't observe…

INCOMPLETE DOMINANCE

Snapdragons: Red, Pink, or White

P ♂ Pure Red x ♀ Pure White (no Pure Pink!!)

F1 ALL Pink

` F2 1 Red: 2 Pink : 1 White

- **Incomplete Dominance:** one allele partially covers the other, producing intermediate phenotype
- **Intermediate phenotype:** in between the two extremes. Genotype is heterozygous

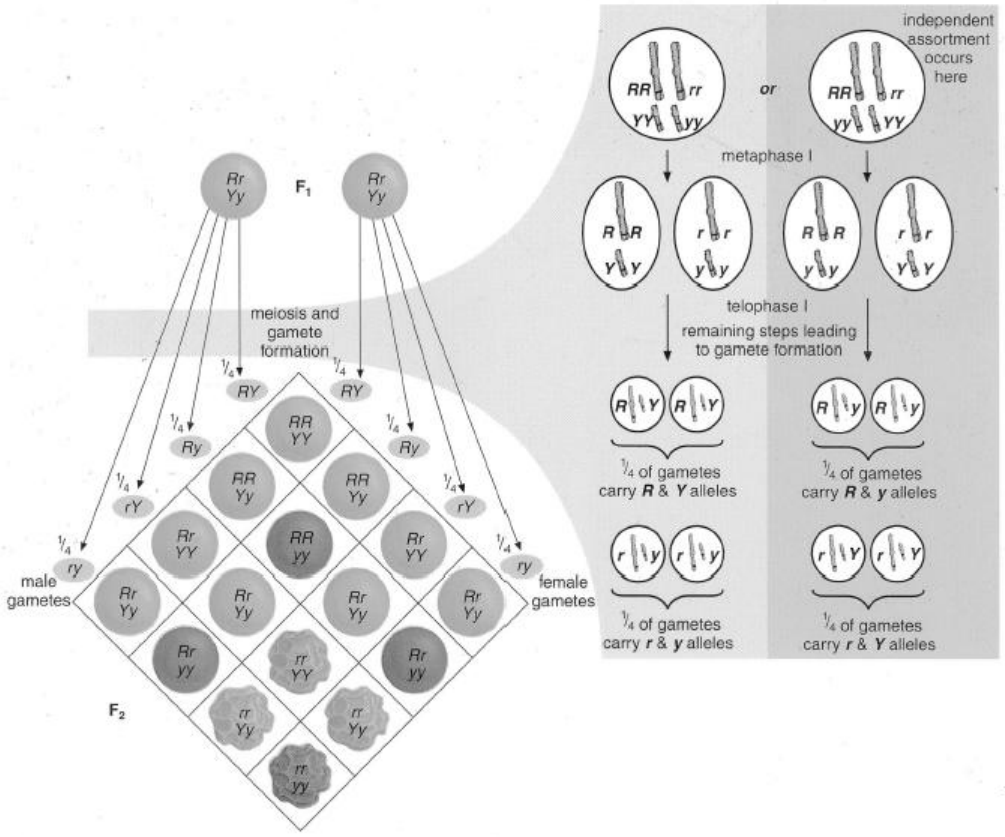
CODOMINANCE

Blood: A, B, AB, O

***Draw diagrams of each blood type

Type	Phenotype	Genotype	Can Accept	Can Donate To
A	A carbohydrates	I^AI^A, I^AI^O	A, O	A, AB
B	B carbs	I^BI^B, I^BI^O	B, O	B, AB
AB	A carbs + B carbs	I^AI^B	A, B, AB, O	AB
O	No carbs	I^OI^O	O	A, B, AB, O

- **Codominance**: two alleles are equally expressed, neither dominates the other
- Has multiple alleles



Name:_____ AE Biology

Chapter 8: Mendelian Genetics

The "need-to-know" terms of genetics

WORDS TO KNOW

Gene

Allele

Dominant

Recessive

Homozygous

Heterozygous

Genotype

Phenotype

Monohybrid

Dihybrid

MENDEL'S DISCOVERIES

Two alleles

Dominance

Principle of Segregation

Principle of Independent Assortment

MODES OF INHERITANCE

Complete Dominance

Incomplete Dominance

Co-Dominance

Name _____ Class _____ Date _____

unit 18. basic principles of heredity

ACTIVITY 18-1. MENDELIAN GENETICS

Many of the basic concepts of heredity were worked out in the mid-1800s by the Austrian monk Gregor Mendel (1822-1884). Mendel cultivated garden peas, which he used to study plant inheritance. From these experiments, Mendel concluded that each hereditary trait is controlled by two separate factors, one from each parent, and that these factors are passed on unchanged from generation to generation. Mendel knew nothing of chromosomes or genes. However, what he called "factors" are now known to be genes, which are found on the chromosomes.

Mendel was very careful in his studies to use plants that "bred true"—that is, plants that showed the same traits generation after generation. Also, he studied only seven different traits, and there were two contrasting forms for each trait.

LAW OF DOMINANCE

When Mendel crossed two true-breeding pea plants that showed one pair of contrasting traits, only one of these traits was evident in the resulting offspring. For example, if he crossed a tall plant and a short plant, all offspring were tall. The trait that was expressed was described as *dominant*, while the trait that did not show in the offspring was *recessive*. Of the pairs of contrasting traits that Mendel studied, he found that in each case one trait proved dominant. Tall stems were dominant, short stems recessive; round seeds were dominant, wrinkled seeds, recessive, etc. Mendel concluded that of every pair of contrasting traits, one is dominant and the other recessive.

The pure-breeding parent generation is called the P generation. The offspring of the crosses between members of the P generation are called the first filial, or F_1, generation. Crosses between members of the F_1 generation produce the second filial, or F_2, generation, and so on. In Mendel's experiments members of the F_1 generation were *hybrids*—they were the offspring of unlike parents.

Questions

1. In Mendel's experiments, he crossed pea plants with green pods with plants with yellow pods. He found that all the offspring had green pods.
   a. The plants used in the original cross are members of the _____ _____ generation.
   b. The offspring of the cross make up the _____ filial, or _____, generation.
   c. The pod color that is dominant is _____, while the pod color that is recessive is _____.
2. What is a hybrid?

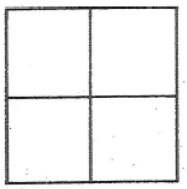
TEST CROSS

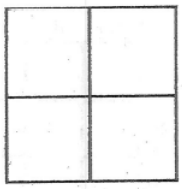
A test cross is a method for determining whether an organism that shows a dominant trait is pure dominant for that trait or whether it is heterozygous. In a test cross, the organism in question is crossed with a pure recessive for the trait. If the test organism is heterozygous, some of the offspring of the cross will show the recessive trait. If the test organism is homozygous dominant, none of the offspring will show the recessive trait. Large numbers of offspring are necessary for valid results.

Questions

1. In guinea pigs, black coat color is dominant over white. How would you find out whether a black guinea pig is homozygous for coat color (BB) or heterozygous (Bb)?

2. Using the Punnett squares below, show how the results of a test cross would differ with a guinea pig that was homozygous dominant for coat color (BB) and one that was heterozygous for coat color (Bb).



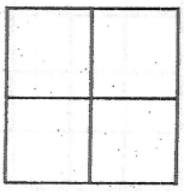


BLENDED INHERITANCE

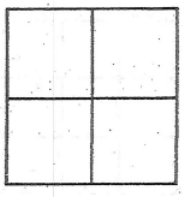
Although all the traits that Mendel studied showed simple dominant or recessive forms, not all traits show this pattern of inheritance. In *blended inheritance*, or *incomplete dominance*, the heterozygous organism is different in appearance from either of the homozygous parents. The trait in question is intermediate in character between the two contrasting homozygous traits. For example, crossing pure red (RR) and pure white (WW) Japanese four-o'clocks results in an F_1 generation in which all the flowers are pink (RW).

Question

As examples of blended inheritance, show a cross between a pure red snapdragon (RR) and a pure white snapdragon (WW). In the second square show a cross between two members of the F_1 generation (RW × RW). For each cross, give the phenotypes of the offspring.



Phenotypes: _____



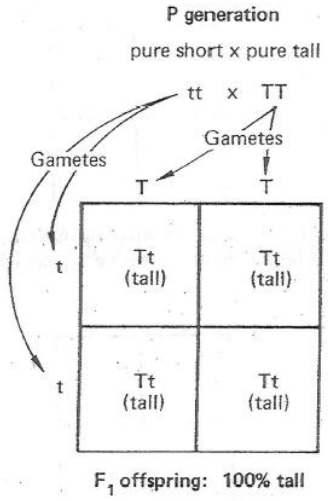
Phenotypes: _____

Name _____ Class _____ Date _____

PUNNETT SQUARES

The Punnett square is a convenient method for visualizing genetic crosses. The boxes that make up the square show all possible zygotes resulting from a cross of gametes bearing a specific trait. The letters representing each possible type of sperm are placed along the top of the square, and those for each possible type of egg along the side. For example, in a pea plant that was heterozygous for stem length (Tt), half the gametes would receive the dominant factor for stem length (T) and half would receive the recessive (t). Thus, the plant would produce two types of gametes. A plant that was pure dominant (TT) or pure recessive (tt) would produce only one type of gamete—T or t respectively.

A cross between a homozygous tall plant (TT) and a homozygous short plant (tt) is shown below.



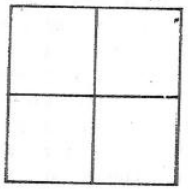
F_1 offspring: 100% tall

The F_1 generation is all heterozygous tall. The physical appearance of an individual is called the *phenotype*. Thus, the phenotype of all members of the F_1 generation is tall. The *genotype*, on the other hand, is the genetic makeup of the individual. In this case all members of the F_1 generation have a heterozygous, or hybrid, genotype. The genotypes of the P generation were homozygous dominant and homozygous recessive.

Questions

1. The physical appearance of an individual is its _____, while the genetic makeup of an individual is its _____.

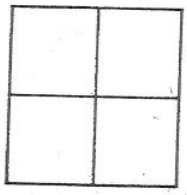
2. Use a Punnett square to show the offspring of a cross between two pea plants that are heterozygous for stem length (Tt × Tt). Give the phenotypes and genotypes of the offspring.



Phenotypes: _____

Genotypes: _____

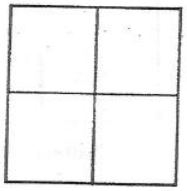
3. Use a Punnett square to show the offspring of a cross between a pea plant that is homozygous tall (TT) and one that is heterozygous (Tt). Give the phenotypes and genotypes of the offspring.



Phenotypes: _____

Genotypes: _____

4. Use a Punnett square to show the offspring of a cross between a pea plant that is heterozygous tall and one that is homozygous recessive for stem length. Give the phenotypes and genotypes of the offspring.



Phenotypes: _____

Genotypes: _____

LAW OF INDEPENDENT ASSORTMENT

Following his crosses of plants with one pair of contrasting traits, Mendel did crosses of plants that showed two pairs of contrasting traits. Such a cross might involve a plant with long stems and round seeds (both dominant) and one with short stems and wrinkled seeds (both recessive). The first plant could be represented as TTRR, the second as ttrr. Each plant would produce only one type of gamete—one would be TR and the other tr. All offspring of the cross would be hybrids with long stems and round seeds (TtRr).

To find out whether there was any relationship between the two traits—for example, whether the dominant traits segregated together—Mendel allowed the hybrid plants to undergo self-fertilization. This is a *dihybrid*

Name_____ Class_____ Date_____

cross, a cross involving organisms that are hybrid for two traits. The results of such a cross showed that the factors (genes) for each trait were segregated independently of any others in the course of gamete formation. This is Mendel's law of independent assortment. It has since been found that there are exceptions to this law.

Questions

1. What is Mendel's law of independent assortment?

2. Work out the following dihybrid cross. Round seeds are dominant over wrinkled seeds, and yellow seeds are dominant over green seeds. A plant that is hybrid for both traits (RrYy) is allowed to undergo self-fertilization (RrYy × RrYy).

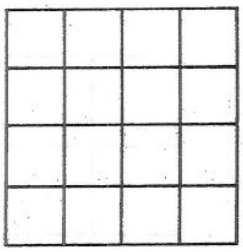
   a. The four types of gametes formed are _____,
   _____, _____, and _____.

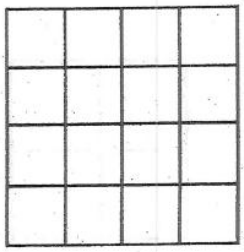
   b. Fill in the Punnett square below. Give the phenotypes of the offspring of this cross and the percentage of each phenotype produced.

	RY	Ry	rY	ry
RY				
Ry				
rY				
ry				

3. In the dihybrids that Mendel worked with, the genes for the individual traits were located on separate chromosomes. If the genes for two or more of these traits had been located on the same chromosome, would Mendel have developed his law of independent assortment?

4. Using the Punnett squares below, work out the following crosses.
   a. TTYY × TtYy b. rrYy × RRyy





LAW OF SEGREGATION

In another experiment, Mendel allowed the hybrid members of the F_1 generation to undergo self-fertilization. The offspring of this cross were the F_2 generation. Of the F_2 generation, three-fourths showed the dominant trait and one-fourth showed the recessive trait. This showed that although members of the F_1 generation all showed the dominant trait, these plants also carried the recessive factor (gene), and that this factor was passed on to the F_2 generation. These results led Mendel to the conclusion that each trait is controlled by a pair of factors, one from each parent. (The F_1 hybrids obviously carried the dominant factor of one parent and the recessive factor of the other parent.) This is Mendel's law of segregation.

Since the gametes fuse in fertilization, each gamete must carry only one of the factors, and the zygote formed by the fusion of the two gametes then carries two, one from each parent. In the formation of gametes, the two factors must separate, or *segregate*. Each gamete receives one factor for each trait. The dominant trait is expressed whenever the dominant factor (gene) for that trait is present. For example, in the experiments on stem length, all members of the F_1 hybrid generation were tall. Only an organism posessing two recessive factors for a given trait will show the recessive trait.

An individual with two dominant or two recessive genes is said to be *homozygous*, while the hybrid, with one dominant and one recessive gene, is *heterozygous*. The dominant trait is shown by two capital letters (TT for tallness, for example), and the recessive by two lower case letters (tt for shortness). The homozygous dominant is TT, the homozygous recessive is tt, and the hybrid is Tt.

Questions

1. What is Mendel's law of segregation?

2. In the pea plants studied by Mendel, how many factors controlled a given trait?

   _____

3. Use G for green pods (dominant) and g for yellow pods (recessive).
   a. A pea plant that is homozygous dominant for green pods would be shown as _____.
   b. A pea plant that is heterozygous for green pods would be shown as _____.
   c. A pea plant that is homozygous recessive for yellow pods would be shown as _____.

Name _____ Class _____ Date _____

MULTIPLE ALLELES

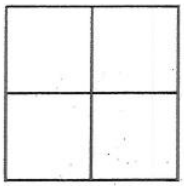
All traits discussed so far have been controlled by a single pair of alleles. However, there are some traits, such as blood type in humans, that involve more than two genes. Human blood type involves three genes—A, B, and O. Genes A and B are dominant, while O is recessive. The four human blood types are A, B, AB, and O. Genotypes of multiple alleles are shown using the capital letter I for dominant and lower case i for recessive. Thus, for example, type A blood is genotype I^A.

Questions

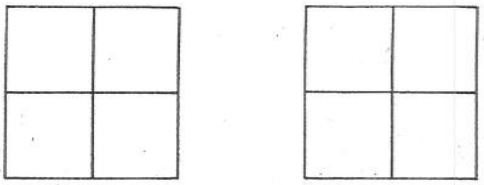
1. What are multiple alleles?

2. Two traits in humans that are determined by multiple alleles are _____ and _____.

3. A man with type AB blood marries a woman with type O blood. Using the Punnett square below, show all possible genotypes of their offspring.



4. Could a mother with type B blood and a father with type O blood produce offspring with type AB blood? Use the Punnett squares below to check your answer.



MUTATIONS

Mutations are stable changes in the hereditary material. *Somatic mutations* are genetic changes within the body cells. This type of mutation can be passed on only to other body cells by mitotic cell division. *Germinal mutations*, which are mutations in the sex, or *germ*, cells, can be passed on to succeeding generations.

Any trait can undergo a mutation at any time, but the rate of mutation is usually very low. Certain types of radiation and various chemicals are known to cause mutations. Mutations are generally recessive. Thus, they are usually masked by dominant genes unless they are sex-linked. Muta-

Genetics Practice Problems - Simple Worksheet

1. For each genotype below, indicate whether it is heterozygous **(He)** or homozygous **(Ho)**

AA _____	Ee _____	Ii _____	Mm _____
Bb _____	ff _____	Jj _____	nn _____
Cc _____	Gg _____	kk _____	oo _____
DD _____	HH _____	LL _____	Pp _____

2. For each of the **genotypes** below determine what **phenotypes** would be possible.

Purple flowers are dominant to white flowers.

PP _____

Pp _____

pp _____

Round seeds are dominant to wrinkled seeds.

RR _____

Rr _____

rr _____

Brown eyes are dominant to blue eyes

BB _____

Bb _____

bb _____

Bobtails in cats are recessive.

TT _____

Tt _____

tt _____

3. For each **phenotype** below, list the **genotypes** (remember to use the letter of the dominant trait)

Straight hair is dominant to curly. Pointed heads are dominant to round heads.

_____ straight

_____ straight

_____ curly

_____ pointed

_____ pointed

_____ round

4. Set up the Punnet squares for each of the crosses listed below. *Round seeds are dominant to wrinkled seeds.*

Rr x rr

What percentage of the offspring will be round? _____

RR x rr

What percentage of the offspring will be round? _____

RR x Rr

What percentage of the offspring will be round? _____

Rr x Rr

What percentage of the offspring will be round? _____

Practice with Crosses. Show all work! **SHOW ALL WORK!**

5. A TT (tall) plant is crossed with a tt (short plant).

   What percentage of the offspring will be tall? _____

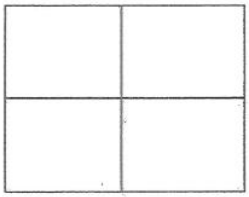
6. A Tt plant is crossed with a Tt plant.

   What percentage of the offspring will be short? _____

Punnett Square Activity

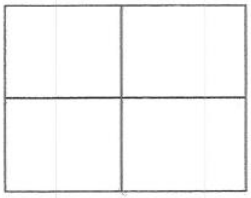
Procedure

1. Study the genetic problems below. Complete the Punnett Square for each by first writing the parental genotypes in the correct place. Determine the possible genotypes of the offspring. For each combination, describe the trait the offspring would exhibit, which is called the phenotype.



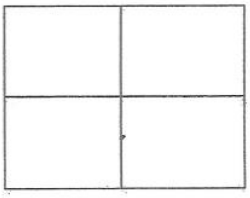
Silkworms
dominant gene: yellow cocoon (C)
recessive gene: white cocoon (c)
parents: CC x cc

List possible genotypes and phenotypes:



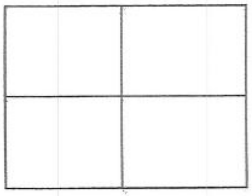
Guinea pigs
dominant gene: short fur (F)
recessive gene: long fur (f)
parents: Ff x ff

List possible genotypes and phenotypes:



Mice
dominant gene: black eyes (E)
recessive gene: red eyes (e)
parents: Ee x Ee

List possible genotypes and phenotypes:



Roses
dominant gene: red flowers (F)
recessive gene: white flowers (f)
codominance: pink flowers (Ff)
Parents: white flower x pink flower

List possible genotypes and phenotypes:

Genetics with a Smile

Name: _____

Part A: Smiley Face Traits
(1) Obtain two coins from your teacher. Mark one coin with a "F" and the other with a "M" to represent each of the parents. The parents are heterozygous for all the Smiley Face traits.
(2) Flip the coins for parent for each trait. If the coin lands with heads up, it represents a dominant allele. A coin that lands tails up indicates a recessive allele. Record the result for each person by circling the correct letter. Use the results and the Smiley Face Traits page to determine the genotype and phenotype for each trait.

Trait	Female	Male	Genotype	Phenotype
Face Shape	C c	C c		
Eye Shape	E e	E e		
Hair Style	S s	S s		
Smile	T t	T t		
Ear Style	V v	V v		
Nose Style	D d	D d		
Face Color	Y y	Y y		
Eye Color	B b	B b		
Hair Length	L l	L l		
Freckles	F f	F f		
Nose Color	R Y	R Y		
Ear Color	P T	P T		

Part B: Is it a boy or girl?
To determine the sex of your smiley face, flip the coin for the male parent. Heads would represent X, while tails would be Y.

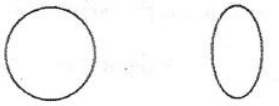
	Female	Male	Genotype	Phenotype
Sex	X	X Y		

Part C: Create Your Smiley Face!
Use the Smiley Face Traits chart and your results from Part A to create a sketch of your smiley face in the box. Once you have completed the sketch, use the drawing tools in Microsoft Word to create your smiley face!

Two things to remember ...
√ Do not add color on the computer! Print a black and white copy and then use crayons or colored pencils to finish it.
√ Don't forget to give your smiley face a name! You will also need to include your name as parent and your class hour.

Smiley Face Traits

Face Shape
Circle (C) Oval (c)



Eye Shape
Star (E) Blast (e)

Hair Style
Straight (S) Curly (s)

Smile
Thick (T) Thin (t)

Ear Style
Curved (V) Pointed (v)

Nose Style
Down (D) Up (d)

Face Color
Yellow (Y)
Green (y)

Eye Color
Blue (B)
Red (b)

Hair Length
Long (L)
Short (l)

Freckles
Present (F)
Absent (f)

Nose Color
Red (RR)
Orange (RY)
Yellow (YY)

Ear Color
Hot Pink (PP)
Purple (PT)
Teal (TT)

Sex
To determine the sex, the flip the coin for the male parent. Heads equals X and tails equals Y.

XX - Female - Add pink bow in hair
XY - Male - Add blue bow in hair

Genetics with a Smile
Wrapping It Up!

Name _____

(1) How does your smiley face compare to the ones created by your classmates? Pick two smiley faces that are displayed near your smiley face and compare each of the 12 traits. Indicate the phenotype for each smiley face for each trait in the chart.

Trait	My Smiley Face	Smiley by _____	Smiley by _____
Face Shape			
Eye Shape			
Hair Style			
Smile			
Ear Style			
Nose Style			
Face Color			
Eye Color			
Hair Length			
Freckles			
Nose Color			
Ear Color			

(2) Which smiley face has the most dominant traits? _____ How many? _____ traits

(3) Which smiley face has the most recessive traits? _____ How many? _____ traits

(4) Which traits were a result of incomplete dominance?

(5) What is the probability that a smiley face will have a green face? _____ out of _____ or ____ %

(6) How many smiley faces have a green face, which is a recessive trait? _____ out of _____ or ____ %

(7) How does your predicted probability for a green face (#5) compare to the actual results (#6)? Explain.

(8) What is the probability that a smiley face will have an orange nose? _____ out of _____ or ____ %

(9) How many smiley faces have an orange nose? _____ out of _____ or ____ %

(10) How does your predicted probability for an orange nose (#8) compare to the actual results (#9)? Explain.

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(11) Why did you only need to flip the male parent coin to determine the sex of your smiley face?

(12) How would the smiley faces change if one of the parents were homozygous dominant for all the traits while the other was heterozygous?

(13) How would the smiley faces change if one of the parents were recessive for all the traits while the other was heterozygous?

(14) Uncle Smiley, who is heterozygous for a yellow face, married a woman with a green face. Both of them have always wanted a large family! If they were to have 12 children, what is the probability that the children would have yellow faces? How many would have green faces? Create a Punnett square to to help you find your answers.

(15) Grandma and Grandpa Smiley are heterozygous for the star eye shape. If one of their heterozygous children married a girl with blast-type eyes, what percentage of their grandchildren should have starry eyes? What percent would have blast-type eyes? Create a Punnett square to help you find your answers.

(16) Baby Smiley has curly hair, but neither of her parents do! Is this possible? Create a Punnett square to help you find your answer.

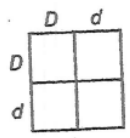
(17) Aunt Smiley has the cutest pointed ears and would love to have children with pointed ears! What type of ears would her husband need to have in order for her to get her wish? Give the genotype and phenotype as part of your answer.

Name _____ Date _____ Class _____

EXPECTED AND OBSERVED RESULTS

In Section 26:2 of your textbook, read about solving genetics problems using the Punnett square.

3. Examine the diagrams below. Each is a step in the Punnett square method. Put the steps in order by writing the numbers 1 to 4 below them on the correct blanks.



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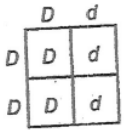

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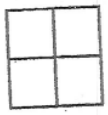

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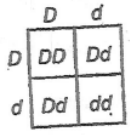


___

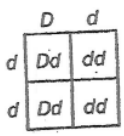
4. What do the letters outside the Punnett square stand for? _____

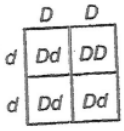
_____

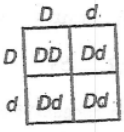
What do the letters inside each box stand for? _____

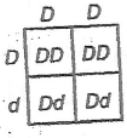
_____

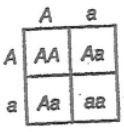
5. Examine the following Punnett squares and circle those that are correct.

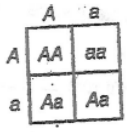


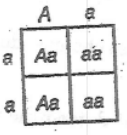


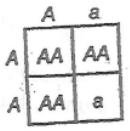




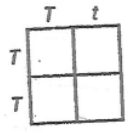


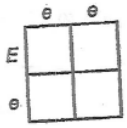


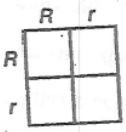


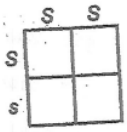


6. Complete the following to determine the expected offspring.









Name: _____ Date:_____ Block:_____

AE Biology Genetics Quiz (30 pts)

1. _____ is often referred to as "The Father of Genetics."

2. List three reasons that peas were good subjects for "The Father of Genetics'" experiments.

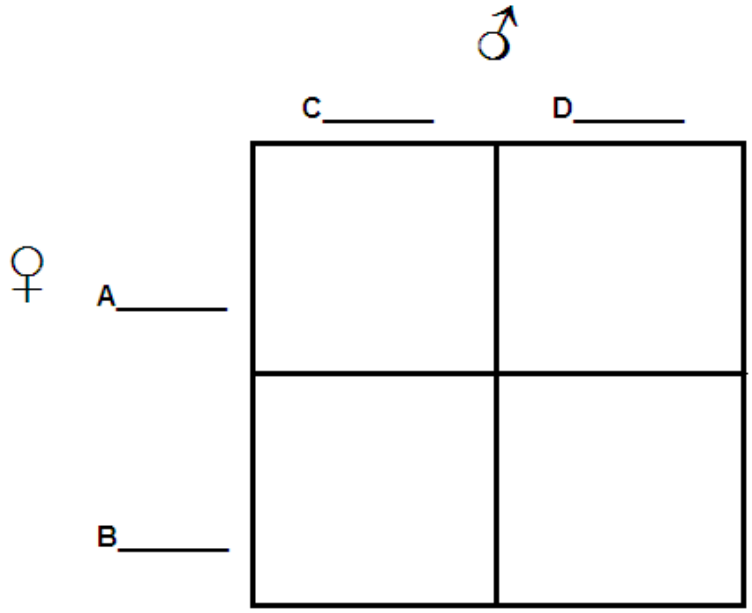
Matching

In the space provided, write the letter of the description that best matches the term or phrase.

_____3. Genetics	**A. homozygous recessive**
_____4. Dominant	**B. has two of the same alleles (word)**
_____5. Alleles	**C. gamete formation**
_____6. rr	**D. the alleles an individual carries**
_____7. Hybrid	**E. heterozygous**
_____8. Inheritance	**F. can cover other traits**
_____9. Phenotype	**G. how a trait is expressed in an individual**
_____10. Segregation	**H. study of inheritance**
_____11. Rr	**I. chromosomes split equally**
_____12. Genotype	**J. genes being passed down**
_____13. Purebred	**K. has a combination of different alleles (word)**
_____14. Meiosis	**L. different versions of the same trait**

3. Round seeds (R) are dominant to wrinkled seeds (r). Fill in the diagram below for the following cross:

A homozygous dominant male x a heterozygous female



4. The genetic material listed on lines A and B came from a(n) _____ cell.

5. The genetic material listed on lines C and D came from a(n) _____ cell.

6. The P generation can also be called the _____ generation.

7. What are the genotypes of the P generation?

8. The F_1 generation can also be called the _____ generation.

9. What are the genotypes of the F_1 generation?

10. What is the ratio of phenotypes in the F_1 generation?

11. In order for a plant to have wrinkled seeds, its genotype must be _____.

12. The principle of _____ says that alleles are separated equally during gamete formation

Crosses Involving Two Traits (continued)

Step 5 genotype ratio 1 GGTT:2 GGTt:2 GgTT:4 GgTt:1 GGtt:2 Ggtt:1 ggTT:2 ggTt:1 ggtt =
1/16 GGTT, 1/8 GGTt, 1/8 GgTT, 1/4 GgTt, 1/16 GGtt, 1/8 Ggtt, 1/16 ggTT, 1/8 ggTt, 1/16 ggtt
phenotype ratio 9 green tall:3 green short:3 yellow tall:1 yellow short =
9/16 green tall, 3/16 green short, 3/16 yellow tall, 1/16 yellow short

EXERCISES

For each exercise, (a) show the parental genotypes, (b) draw out the Punnett square, and (c) answer the question, in the spaces provided.

In mice, the ability to run normally is a dominant trait. Mice with this trait are called running mice (R), The recessive trait causes mice to run in circles only. Mice with this trait are called waltzing mice (r). Hair color is also inherited in mice. Black hair (B) is dominant over brown hair (b).

1. Cross a heterozygous running, heterozygous black mouse with a homozygous running, homozygous black mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

2. Cross a homozygous running, homozygous black mouse with a heterozygous running, brown mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

3. Cross a waltzing brown mouse with a waltzing brown mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

4. Cross a homozygous running, heterozygous black mouse with a waltzing brown mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

5. Cross a heterozygous running, brown mouse with a heterozygous running, homozygous black mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

6. Cross a heterozygous running, heterozygous black mouse with a heterozygous running, heterozygous black mouse. What is the probable phenotype ratio?

   a. _____ b. c. _____

Name:_____ Date:_____

AE Biology Genetics I Test (100 pts)

Fill-Ins

Use the words below to fill in the blanks in the following questions.

Alleles	Gametes	Peas	Segregation
Blending	Genotype	Phenotype	Snapdragons
Dominant	Hybrids	Probability	Sperm
Egg	Meiosis	Purebreds	Test cross
Fertilization	Parental	Recessive	Zygote

1. The unknown genotype of an individual with a dominant phenotype can be determined using a _____.

2. Incomplete dominance can be demonstrated with _____.

3. _____ is an event which creates a zygote.

Reproductive cells, also known as (4)_____, are formed during a process called (5)_____. In females, (6)_____ cells are produced; and in men (7)_____ are produced. According to the Principle of (8)_____, the chromosomes of the parents split equally. When the cells from each parent fuse together, they create a (9)_____. This cell has two (10)_____ for each trait. The likelihood that a specific trait will be expressed is its (11)_____.

When the father of genetics did his first experiments, he started with (12)_____. In the P generation, also known as the (13)_____ generation, he used (14)_____ for each trait so that he could be sure what their genotypes were. Their offspring were considered to be (15)_____ since they were a mix. When tall and short were crossed, the offspring in the F^1 generation were all tall. When this generation was self crossed, the offspring had a (16)_____ ratio of 3 tall : 1 short, and a (17)_____ of 1 TT : 2Tt : 1 tt. It was concluded that being tall was a (18)_____ trait, and being short was a (19)_____ trait. This is a famous experiment because it disproved (20)_____ inheritance.

Matching

Match each term with its best description.

21. _____ Different forms of a particular gene	a. allele
22. _____ Spontaneous change in genetic material	b. gamete
23. _____ Chance of showing incompletely dominant trait	c. genetics
24. _____ Chance of showing a completely dominant trait	d. mutation
25. _____ Example: sperm cell	e. 33%
26. _____ Chance of having a girl	f. 50%
27. _____ The study of how genes are inherited	g. 75%

True or False

Write T for true and F for false.

28. _____heterozygous individuals have two of the same alleles for a particular gene.
29. _____If a disease is recessive, the only way for the child of two normal people to show the disease would be if the parents were heterozygous
30. _____ Dominant traits are only shown in homozygous dominant individuals
31. _____ It's possible for a child who shows a recessive trait to have a homozygous dominant parent
32. _____ A woman shows a recessive trait. She wants children with the recessive trait, so she can only marry a man who has the recessive trait.

Multiple Choice

Choose the best answer for each question or statement.

33. Which of the following is not a good reason why peas make an excellent subject for genetic study?
    a. There are many varieties
    b. They can show complete dominance
    c. They grow quickly
    d. They self-pollinate

34. Before people learned about the rules of inheritance, most people thought that that alleles mixed equally in offspring. This is known as
    a. blending inheritance
    b. combined inheritance
    c. dominant inheritance
    d. mixed inheritance

35. F^1:P::
    a. egg: sperm
    b. grandparents : parents
    c. kids : parents
    d. parents : kids

36. A monohybrid is a
    a. cross for one trait
    b. individual who only expresses one trait
    c. individual with two alleles for the same trait
    d. self-pollinating plant

37. Crosses are done with “either-or” traits because
    a. both traits can be dominant
    b. extremes are easy to distinguish
    c. geneticists can’t make their minds up
    d. traits can mix together this way

38. The type of ear (dangling or attached) that an individual has is their
    a. allele
    b. gene
    c. genotype
    d. phenotype

39. Blood types are a prime example of
    a. blending inheritance
    b. complete dominance
    c. codominance
    d. incomplete dominance

40. The principle of segregation states that
    a. alleles of a gene separate from each other during gamete formation.
    b. different alleles of a gene can never be found in the same organism
    c. each gene of an organism ends up in a different gamete.
    d. each gene is found on a different molecule of DNA.

41. The scientist whose studies formed the basis of modern genetics is
    a. Maxwell
    b. Gene Murray
    c. Gregor Mendel
    d. Dr. Punnett

42. A trait with two dominant alleles that are expressed at the same time is
    a. codominant
    b. incompletely dominant
    c. mutational
    d. often seen in snapdragons

43. Homozygous : hybrid ::
    a. F^1: F^2
    b. genotype : phenotype
    c. hybrid : purebred
    d. purebred : heterozygous

44. For each trait, everyone gets one allele from each
    a. egg cell
    b. F^1 generation
    c. parent
    d. zygote

45. An allele that gets covered by another allele is
    a. being dominated
    b. incomplete
    c. recessive
    d. useless

46. In codominance, there is
    a. an intermediate phenotype
    b. more than one dominant allele
    c. more than one recessive allele
    d. never a recessive allele

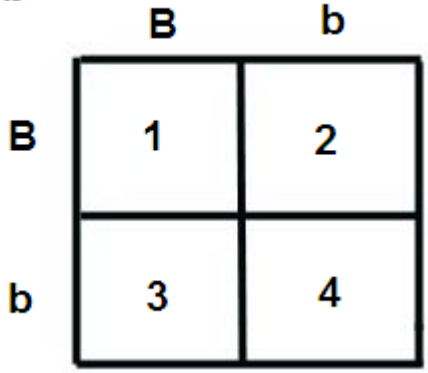
47. F^1: F^2::
    a. egg : sperm
    b. grandparents : parents
    c. kids : parents
    d. parents : kids

48. The hallmark of incomplete dominance is
    a. an intermediate phenotype
    b. blending phenotypes
    b. more than three phenotypes
    c. You can't see it - it's incomplete

49. A test cross which breeds for two traits is called a
    a. bihybrid cross
    b. dihybrid cross
    c. double cross
    d. heterohybrid cross

Questions 50-56 refer to the figure below, which shows a cross between two rabbits. In rabbits, black fur (B) is dominant to brown fur (b). Hint: fill the squares in before answering the questions.

Bb x Bb



50. The device illustrated above, which is used to organize genetic analysis, is called a
    a. genetic graph
    b. phenotypic paradox
    c. Mendelian box
    d. Punnett square

51. The fur in both of the parents in the cross is
    a. black
    b. brown
    c. Homozygous dominant
    d. homozygous recessive

52. The phenotype in the offspring in Box 3 would be
    a. a mixture of black and brown
    b. black
    c. brown
    d. the phenotype can't be determined

53. The genotype ratio (BB : Bb) of the offspring would be
    a. 1 : 1
    b. 1 : 3
    c. 3 : 1
    d. 4 : 0

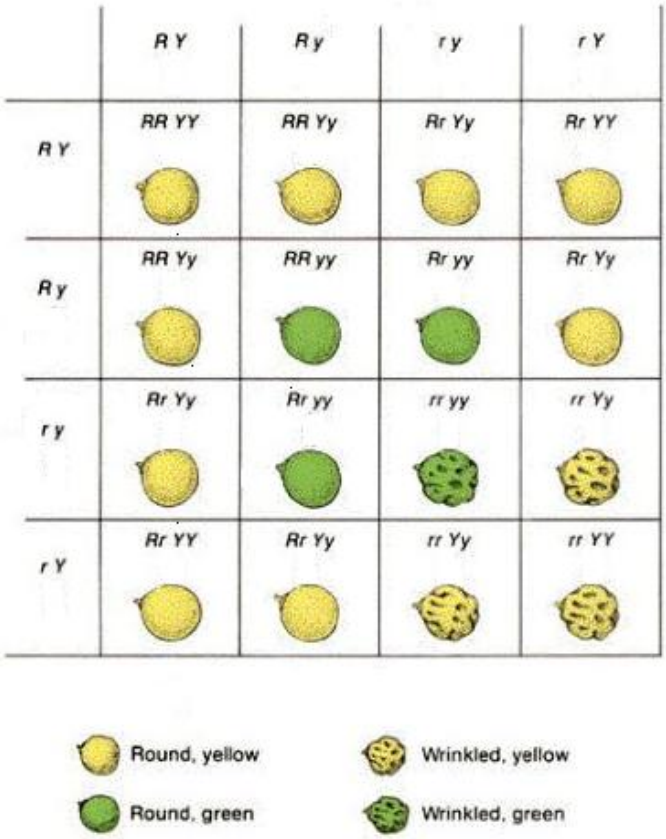
54. The Bb x Bb represents the
    a. F^1 generation
    b. F^2 generation
    c. P generation
    d. mice

55. The individuals in boxes 1-4 represent the
    a. F^1 generation
    b. F^2 generation
    c. P generation
    d. mice

56. If there were 16 offspring, how many would you expect to look just like the parent plants?
    a. 4
    b. 8
    c. 12
    d. 16

Short Answers

Use the tables to answer the questions. Give lots of details and make sure you completely answer the questions.



57. What was each parent's genotype?

58. Which color (green or yellow) is dominant in this cross? Give a specific example which explains how you know.

59. Which shape (wrinkled or round) is dominant in this cross? Give a specific example which explains how you know.

60. What is the *genotype* ratio of the offspring?

61. What is the *phenotype* ratio of the offspring?

62. If there are 32 offspring, how many will be green and round?

Fill the following table in and use it to answer the following questions.

Blood Type	Can donate to:	Can accept from:
A		
B		
AB		
O		

63. Type _____ is the universal donor. Type _____ is the universal receiver.

64. Why can Type A people only donate to the types you listed?

65. What kind of inheritance do you see with blood types? How do we know that?

ESSAY:

How did the father of genetics prove that blending inheritance did not account for how genes are inherited? Be detailed and use an example.

Appendix C – "Genetics II" Unit

This appendix contains all lecture notes, overheads, worksheets, labs, and assessments for the Chromosomal Genetics units in each level.

Appendix C1 – Honors Genetics II

Genetics II. Chromosomal Genetics
Lesson Plan

Day 1:
Review previous unit
Lecture: Chromosome Theory

Day 2:
Lecture: Karyotypes
"Karyotyping"* activity

Day 3:
Lecture: Gender and nondisjunction

Day 4:
Lecture: Sex-linked traits and linked genes
"Sex-Linked Traits"* worksheet
"Sex-Linked Inhertiance"* (do a few practice problems, finish for hw)

Day 5:
Genetic counseling demo
Dog pedigree
Lecture: Pedigrees
"Learning from Pedigrees"* handout
Pedigree practice packet (hw due day 7)

Day 6:
Colorblindness demo: test members of the class and discuss
"A Trait in Human Inheritance"* lab

Day 7:
Review packet problems, review lectures
Assign disease report (due day 10)

Day 8:
Presentation genetic diseases
"Intersexual"* video

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Day 9:

Finish video and discuss
"Colorblindess"* worksheet
Practice problems

Day 10:

Bioethics debates:
"Can we help our child?"*
"What will happen to my baby?"*

Day 11:

Presentations on disease reports
Review for test, practice problems

Day 12:

Unit Test

Genetics II, Lecture 1: (Ch 13.8)

Inheritance isn't always a straightforward process. Mendel couldn't figure everything out because he didn't understand the nature of DNA

CHROMOSOME THEORY- *homologous chromosomes contain homologous alleles*

- Mendel: knew that factors separated equally during gamete formation (principle of segregation)
- **Walter Sutton** (1902)
  - Noticed that homologous chromosomes separated during meiosis
  - Offspring got one homologous chromosome from each parent at gamete formation
  - Hypothesized/realized that homologous chromosomes each had one allele for a trait (each has one allele, so you get one allele from each parent)

    - linked movement of chromosomes during meiosis with Mendel's laws

Once scientists understood that alleles were carried on homologous chromosomes (Chromosome Theory), they could learn even more about how inheritance/ chromosomes/genetic material affect us

- **Fruit flies** are often used for genetic research
  - *Drosophilia melanogaster*
  - small and easy to care for
  - easy to breed
  - quick generation time
  - many offspring
  - chromosomes are easy to observe (large and only 4 pairs)

Scientists actually look at the chromosomes to learn more about genetics

KARYOTYPES *a way to study the physical side of genetic*

- Chromosomes are condensed in mitosis, so scientists take pictures to observe instead of living samples
  - White blood cells: mitosis is induced and stopped at metaphase, stained, photographed
- **Karyotpe:** pictures of chromosomes cut out and arranged in pairs by size, shape, and content (homologous pairs)

What can we learn from karyotypes?

Genetics II, Lecture 2

What can we learn from karyotypes?

SEX DETERMINATION – *X and Y chromosomes*

- **Thomas Hunt Morgan** (1910's)
- Morgan noticed that for all *Drosophilia*
  -females*:* 4 pr homologous
  - males: 3 pr homologous, 1 pr different
    1 like fourth pr in female
    1 smaller, different shaped one
- **Sex chromsomes:** X & Y chromosomes
  X = longer one, in both sexes, all you see in females
  Y = shorter, in all males, only in males
- **Autosomes:** all non-sex chromosomes
- Chromosomes explain 50/50 chance of having a boy or girl

The largest scale genetic problem is when the number of chromosomes is wrong

NONDISJUNCTION ***when chromosomes don't split***

Calvin Bridges while working with flies
Nondisjunction: when chromosomes do not separate correctly in meiosis
*Too many chromosomes
* Too few chromosomes
***trisomy:** extra chromosomes
***monosomy:** only one (too few)

*trisomy usually occurs in smaller chromosomes
-big chromosomes have so much important stuff that you'd die without them

-monosomy of autosomes is usually lethal

The location of alleles on chromosomes plays a large role in the relationships between how different traits are inherited. Scientists study allele location chromosomes by observing photographs of chromosomes.

Once scientists can see where alleles are located, they can hypothesize how traits will be inherited together in progeny, and why inheritance sometimes goes against the Principle of Independent Assortment.

Genetics II, Lecture 3

SEX-LINKED TRAITS

- 1910, Morgan was studying *Drosophilia* and noticed a male with white eyes, assumed that white eyes were recessive since it was rare
- Basic pure-bred cross yields all red in F1
- F2 – still 3:1
  3470:782
  Red: 2459 female
  1011 male
  White: 782 **males**

- All the white-eyed were **male!**
  → **white eye color must be linked to being male**
  → white eye color gene must be found on only the X chromosome, and it's recessive

- **Sex-linked Trait:** trait that is only found on one type of autosome

P X^RX^R x X^rY

F1 X^RX^r x X^RY

F2 X^RX^r or X^RX^R x X^RY or X^rY

Recessive
- White-eyed male can be produced if mother is homozygous or heterozygous with the recessive trait
- White-eyes **female** can be produced if mother is homozygous recessive (X^rX^r) or heterozygous (X^RX^r), and father is recessive (X^rY)

Dominant
- Males and females
- Father can give the allele to only his daughters
- Mother gives to all children if she's homozygous, to half if she's heterozygous

LINKED GENES

Mendel's traits weren't linked with each other, they all occurred and were assorted independently (F2 = 9:3:3:1)

Linked traits that always will be together have only 3 genotypes and 2 phenotypes
3:1 phenotype

- Crossing Over: when homologous chromosomes exchange portions in meiosis, causing new allele cominations
- Alleles that are further apart tend to get separated more, if they're closer together they tend to be inherited together
- **Linked Genes:** on the same chromosome, so close that they are inherited together
- Some genes are hard to detect, so scientists use more observable linked genes to find them
  - Huntington's disease

Pro: less harmful recombination
Con: less diversity, less helpful recombination

- No general rule for how these are spaced and for which genes will be linked

So if the X chromosome carries all this stuff….why aren't women better off than men who have one less X chromosome?

INACTIVATED X CHROMOSOME

- Part of X chromosome is covered by proteins whose code is on that part of the chromosome. Once the gene and other genes get covered up enough, they have to stop coding and the process is done
- This results in Barr bodies in female white blood cells
- Used in forensics
- Responsible for calico cats, sometimes when each eye is a different color, and other various "patched" phenotypes

Karyotyping

Purpose

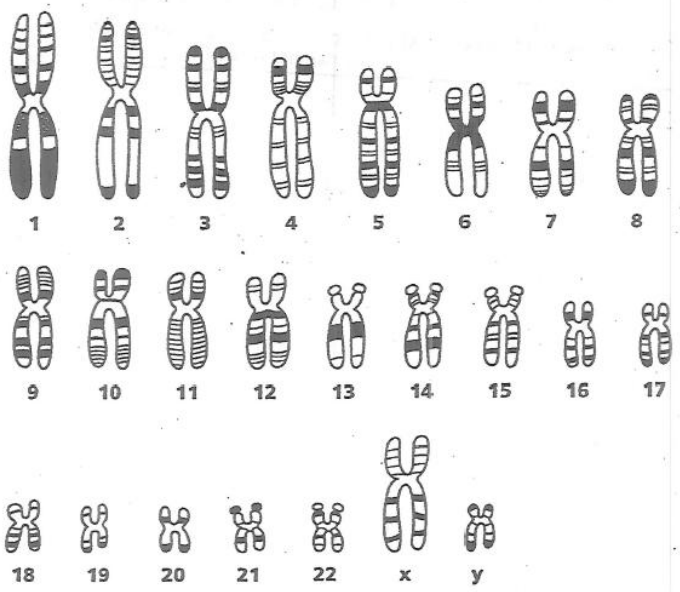
As a medical lab technician, one of your jobs is to assist with prenatal testing. Currently, you are working on the case of Mr. and Mrs. Smith. Mrs. Smith is pregnant, and her doctor has recommended amniocentesis, which is a type of prenatal testing. You have been given photomicrographs of the chromosomes in the unborn baby's cells, which were obtained through amniocentesis. Your job is to complete and analyze a karyotype of these cells to determine the sex of the Smiths' baby and whether the baby is normal or has Down syndrome.

Background

Humans have 46 chromosomes in every diploid ($2n$) body cell. The chromosomes of a diploid cell occur in **homologous pairs**, which are pairs of chromosomes that are similar in size, shape, and the position of their centromere. In humans, 22 homologous pairs of chromosomes are called **autosomes**. The twenty-third pair, which determines the individual's sex, make up the **sex chromosomes**. Females have only one type of sex chromosome, which is called an **X chromosome**. Males have two types of sex chromosomes, an X chromosome and a much smaller **Y chromosome**. The diagram at the top of the next page shows each of the 22 types of autosomes and the 2 types of sex chromosomes.

A karyotype is a diagram that shows a cell's chromosomes arranged in order from largest to smallest. A karyotype is made from a photomicrograph (photo taken through a microscope) of the chromosomes from a cell in metaphase. The photographic images of the chromosomes are cut out and arranged in homologous pairs by their size and shape. The karyotype can be analyzed to determine the sex of the individual and whether there are any chromosomal abnormalities. For example, the karyotype of a female shows two X chromosomes, and the karyotype of a male shows an X chromosome and a Y chromosome.

Human Chromosomes



NAME _____

CHAPTER 26 ENRICHMENT ACTIVITY Genetics Problem Solving

Sex-Linked Traits (continued)

Step 5 State the genotype and phenotype ratios of the offspring.
1 X^HX^h: 1 X^HY = ½X^HX^h, ½ X^HY
1 normal female: 1 normal male = ½ normal females, ½ normal males

EXERCISES

For each exercise write out the Punnett square where appropriate, and answer the questions in the spaces provided.

1. A woman who is heterozygous for hemophilia, marries a normal man. What will be the possible phenotype ratio of their children?

_____

2. A woman who is a carrier for hemophilia marries a hemophiliac man. What will be their childrens' possible phenotypes?

_____

_____

3. A hemophiliac woman has a phenotypically normal mother. What are the genotypes of her mother and father?

_____

_____

4. A phenotypically normal woman has phenotypically normal parents. However, she has a hemophiliac brother. (a) What are her chances of being a carrier for hemophilia? (b) If she is a carrier and marries a normal male, what is the chance of a child being a hemophiliac?

a. _____

b. _____

5. A phenotypically normal man who has a hemophiliac brother marries a homozygous normal woman. What is the probability that any of their children will be hemophiliac?

_____

6. If a normal-sighted woman whose father was color-blind marries a color-blind man, what is the probability that they will have a son who is color-blind? What is the probability that they will have a color-blind daughter?

_____

7. What is the probability that a color-blind woman who marries a man with normal vision will have a color-blind child?

_____

8. In fruit flies, white eyes is a sex-linked recessive trait. Normal eye color is red. If a white-eyed male is crossed with a heterozygous female, what proportion of the offspring will have red eyes?

_____

NAME _____

SEX-LINKED INHERITANCE

1. A normal woman whose father was color-blind marries a normal man. What kinds of children would be expected and in what proportion?

2. In cats the genotype BB is black. Bb is tortoise shell, and bb is yellow. The gene is on the X chromosome. A tortoise shell female is crossed with a black male. What offspring would be expected? Would you expect to find any tortoise shell males? Why?

3. In man color blindness is due to a sex-linked recessive while blue eyes are due to an autosomal recessive. Two brown-eyed persons with normal vision produce a blue-eyed color blind son. What are the genotypes of the parents? What fraction of the children would be blue-eyed, color blind daughters?

4. A blue-eyed woman whose father was color blind marries a brown-eyed man whose mother was blue-eyed. What proportion of sons would be blue-eyed and color blind?

5. A man whose father was hemophiliac, but whose own blood is normal, marries normal woman with NO record of hemophilia in her ancestry. What is the chance of hemophilia in their children?

6. A woman whose father was hemophiliac, but who is not herself a "bleeder" marries a normal man.

a) What is the chance of hemophilia in their children?

b) These parents have a normal (nonhemophilic) son. What is the probability that their next son will be normal?

7. What is the chance of hemophilia among sons of a daughter of the above marriage if the daughter marries a normal man?

8.The black and yellow pigments in the coats of cats is controlled by a sex-linked incomplete dominant pair of alleles. Hetereozygous female cats show "tortoise-shell", having areas of black and areas of yellow in its coat. A calico cat has a litter of 8 kittens: 1 yellow male, 2 black males, 2 yellow females and 3 calico females. What is the color of the father?

LEARNING FROM PEDIGREES

One key to successful genetic counseling is an accurate family history. A good way of illustrating the history is in the form of a pedigree chart. Different kinds of inherited conditions will show different patterns of heredity in a pedigree chart.

Consider three types of patterns of heredity:

a. a *dominant* condition carried on an autosome (autosomal dominant)

b. a *recessive* condition carried on an autosome (autosomal recessive)

c. a *recessive* condition carried on the X chromosome (X-linked recessive)

Study the pedigrees and indicate:

1. the type of inheritance shown by each
2. your reasoning for your answer
3. the probability ratio in each case
4. a particular genetic disorder that might be illustrated by each case

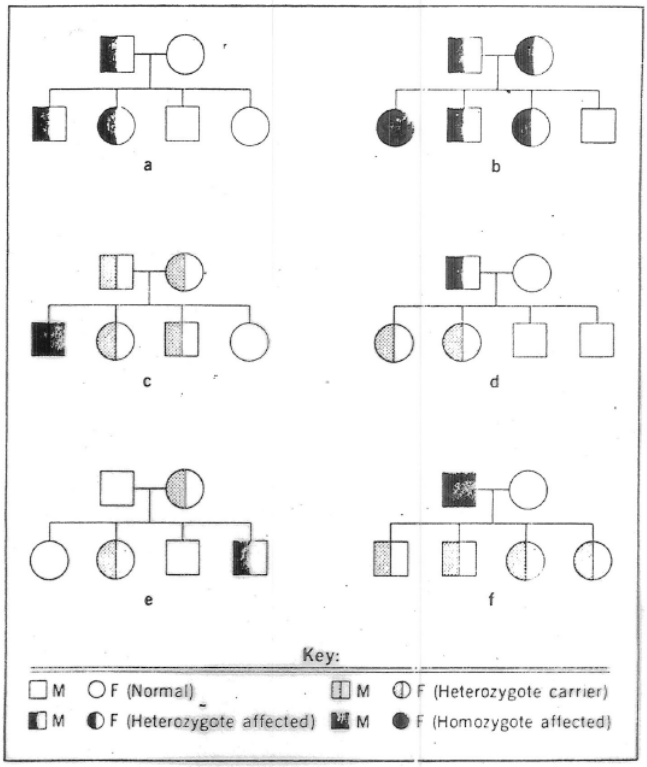
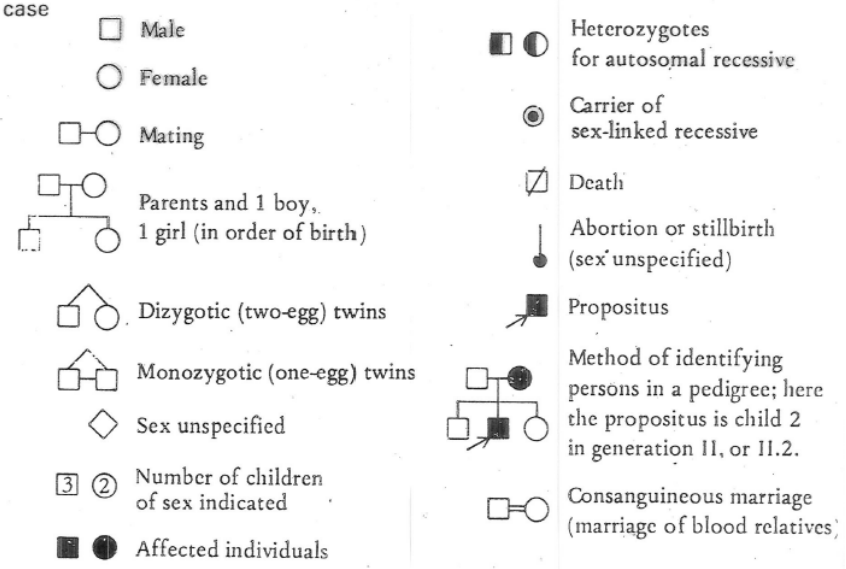


FIGURE 3.12

Symbols used in human pedigree analysis.



A TRAIT IN HUMAN INHERITANCE

Information

Red-green color blindness is one human trait the genetics of which is well understood. From the following pedigrees you should be able to determine which allele (normal color vision or colorblindness) is dominant, and whether or not the gene is sex-linked.

Figure 6-9 (pg.177) shows two pedigrees for colorblindness. Darkened circles or squares represent individuals that are colorblind. Nondarkened circles or squares represent individuals with normal vision.

1. What evidence indicates whether the allele for colorblindness is dominant or recessive?

2. What evidence indicates whether the allele for colorblindness is sex-linked?

Now predict the expected results of a mating between a colorblind man and a woman homozygous for normal color vision.

3. What is the predicted fraction of male offspring who will have normal vision? _____

4. What is the predicted fraction of male offspring who will be colorblind? _____

5. What is the predicted fraction of female offspring who will have normal vision? _____

6. What is the predicted fraction of female offspring who will be colorblind? _____

Now predict the results of a mating between a carrier woman and a man with normal color vision.

7. What is the predicted fraction of male offspring who will have normal vision? _____

8. What is the predicted fraction of male offspring who will be colorblind? _____

9. What is the predicted fraction of female offspring who will have normal vision?_____

10. What is the predicted fraction of female offspring who will be colorblind? _____

Information

Another sex-linked character is hemophilia. The gene for this condition, in which blood clots extremely slowly, is carries on the X chromosome. As in color blindness, it takes but 1 recessive allele for a man to be hemophiliac, and it takes 2 alleles to produce hemophilia in a woman.

Figure 6-10 (pg. 178) shows the distribution of hemophilia among certain royal families of Europe.

11. List the mothers who must have been carriers.

12. The present British royal family descended from Edward VII. What must be true of the hemophiliac trait in that line of descent?

A few families have been discovered in which both the recessive allele for hemophilia and the recessive allele for colorblindness are present in the same woman. Assume that a husband is free of both of these inherited defects. Also assume the wife has one recesssive allele on one X chromosome and the other recessive allele on the other X chromosome.

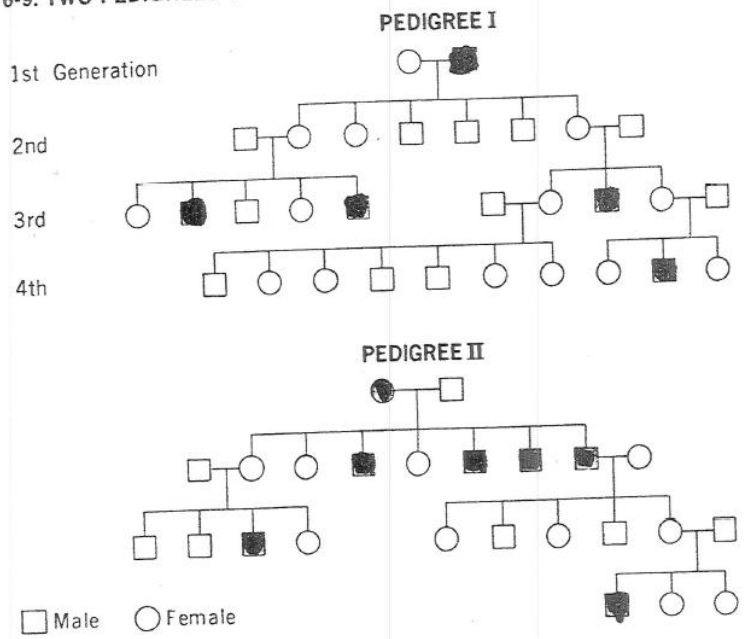
Woman's genotype is $X^{Hc}X^{hC}$

13. What does this information tell you about the different possible genetic make-ups of her father? (father's genotype possibilities)

_____ ___ or _____ most probable_____

14. What probable sons and daughters can be produced in this family?

6-9. TWO PEDIGREES OF COLOR BLINDNESS



COLORBLINDNESS

Using the pedigrees, answer the following questions:

Write the genotypes of each individual next to each figure.

1. Is the allele for colorblindness dominant or recessive? _____

   How can you tell?

2. Is it X-linked or not? _____

   How do you know?

Predict the expected results of a mating between a colorblind man and a woman who is colorblind for normal color vision.

3. Among their male offspring, what fraction would be normal vision?

4. What fraction would be colorblind? _____

5. Among their female offspring, what fraction would have normal vision? _____

6 What fraction would be carriers? _____

7. What fraction would be colorblind? _____

Predict the expected results of a mating between a carrier woman and a man woth normal color vision.

8. Among their male offspring, what fraction wooulld have mormal vision? _____

9. What fraction would be colorblind? _____

10. Among their female pffspring, what fraction woould have normal vision?_____

11. What fraction would be carriers? _____

12. What fraction would be colorblind? _____

CASE STUDY 3C

WHAT WILL HAPPEN TO MY BABY?

When Martha found out she was pregnant, she was extremely happy. She already had a wonderful little girl who was healthy so when they had an ultrasound, they were shocked that the doctor didn't say everything was alright. Her face showed worry and Martha asked what was wrong. Dr. Hendrix said the head of the baby looked small and she had to send the ultrasound out to an expert.

When the results came back it confirmed that Martha's baby had anencephaly, a condition where the brain and head are abnormally small, sometimes absent.

"Will my baby live?", asked Martha.

"It will probably live to be born, but will not live very long after birth, stated Dr. Hendrix, But, some parents in California have donated the organs from a child with a similar condition to other babies soon after birth. We could do that."

Dr. Hendrix was talking about the case in California where parents placed their anencephalic baby on a respirator at birth and donated her heart, lungs and kidneys to babies waiting for organs.

Martha thought about her other choices. Should she carry a baby to term just to have it die? Could she do this?

QUESTIONS FOR CASE STUDY 3C

1. What should Martha do? List three possible things she might do.
2. What reasons could Martha give for carrying her baby and donating the organs?
3. What reasons could she give to abort the baby?
4. Who could Martha go for help with this decision?
5. If Martha found out that there might be a chance that her baby would be born dead and the organs would not be usable, should this make a difference in her decision?

WHAT WILL HAPPEN TO MY BABY?

NOTES ON CASE STUDY 3C

- Anencephaly is caused by a number of genes and is related to other neurospinal disorders (such as spina bifida).
- Occurs in the population at a 1/1000 ratio of live births.
- The condition has a 1:3 ratio of males to females.
- The recurrence risk for those who have had a child with the condition is 5%.
- Alpha Fetal Protein is synthesized by the fetal liver and rises in the first few months of pregnancy and levels off at 16 weeks. Then it slowly declines. A test for this called a Maternal Serum Alpha Fetal Protein (MSAFP) test can be done early in the pregnancy and an elevated level might indicate some neural problem such as anencephaly which can be confirmed by ultra sound.
- Because an anencephalic infant is not dead at the time organs are removed (brain stem functioning still occurs), removal of the organs causes death and therefore violates murder and the dead donor rule. But because the child has no chance for life, the removal of the organs does not harm him/her in anyway.

CASE STUDY 3E

CAN WE HELP OUR CHILD?

Reverend and Ms. Petty had lived through many difficult times. Their first two children were born with a genetic disease called Hurler's syndrome and one had died already. Children with this disease are born normal and progressively get worse. During the first year their appearance becomes grotesque. This includes an enlargement of the face, lips and tongue. Blindness, deafness and mental retardation occur in most children. Their hands become claw-like and the abdomen enlarges. These children die by age 10.

Doctors had developed a test for the Hurler's gene recently and now Ms. Petty was pregnant again. She and her husband were, of course, active church members and their religion didn't believe in birth control or abortion. So, the couple knew they would have the baby whether it had Hurler's syndrome or not. But their doctor, Dr. Gillespie, had read of a new and experimental treatment for Hurler's before the baby is born.

Using fetal surgery (operating on a fetus while it is still inside the mother) doctors can implant the tissue from an aborted fetus into the baby's brain. In tests with animals this was very successful and it had been done on a few other fetus' with good success.

The Petty's didn't want to think about it, but decided to go ahead with the test to see whether their child had Hurlers. The test showed it did have the disease. Now, Dr. Gillespie, reminded them, they could have the treatment.

QUESTIONS FOR CASE STUDY 3E

1. Should the Pettys have this treatment?
2. How would this treatment come in conflict with their ideas and the ideas of their religion?
3. What arguments would you use if you were Dr. Gillespie?
4. Mr. Petty's direct superior in the church has come to talk to the couple. What arguments would you use to stop the Pettys from having this treatment if you were the superior?
5. How would this change if the fetus donating the cells, were being offered from a friend who was pregnant?

CAN WE HELP OUR CHILD?

NOTES ON CASE STUDY 3E

• In January of 1994, the government lifted the ban for use of fetal tissue for experimentation in Parkinson's Disease.

•Some of the alternatives to the use of fetal tissue of abortuses are: ectopic pregnancies (pregnancies that occur in the fallopian tubes and therefore are life threatening to the mother), spontaneous abortions, still births, and the placenta and yolk sac.

• One fear of the widespread use of fetal tissue is the commercialization of the tissue. Using money to encourage women to abort is a great fear of those who are against abortion as a right. This, they feel, would encourage many more abortions.

Name _____ Date _____

Genetic Disorders Research Assignment

Genetic disorders can cause an extremely wide range of problems in humans. For this assignment, you will find a genetic disorder to discuss. The disorder must be either a chromosomal disorder (nondisjunction or malformed chromosomes), or an example of a sex-linked trait. Everyone will report on a different disease. We'll use a first-come, first-serve system.

Your write-up should include:

- What the disease is and its symptoms
- Important statistics (average age of onset, rate of recurrence in following pregnancies, percent of population affected, etc.)
- Tests for the disease, and how early it can be detected
- Treatment plans for the disease
- The cause of the disease, and how it is passed down through generations
- References for all information or pictures you gather in your research

- An example of a karyotype of a person afflicted with the disease will also be included, with the identifying feature pointed out (site of the gene or point of nondisjunction)

- Feel free to include photos of a subject afflicted with the disease, or include any other interesting information in your report!

The report should be about a page long, two pages at the very most, not including any figures or references. Make sure to label your figures, and to cite information within the text where appropriate. Be prepared to give the class a brief description of the disease you choose.

Name:_____ Date:_____ Block:_____

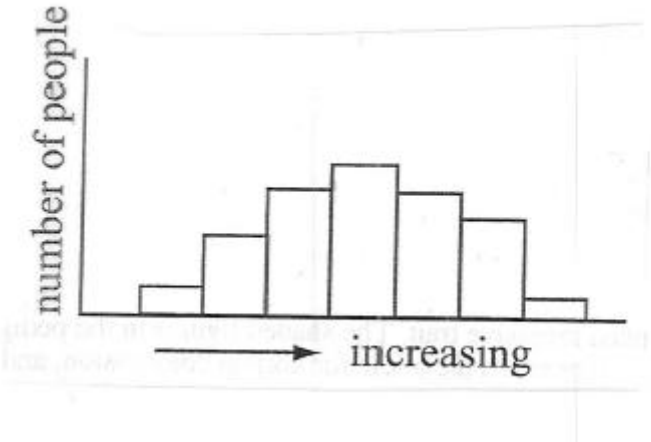
Honors Biology Genetics (Ch 13.1-7) Test (100 pts)

1. The genotypes that cannot be determined by observing the phenotype of the offspring are
    a. codominant
    b. codominant and homozygous recessive
    c. homozygous cominant and heterozygous dominant
    d. homozygous dominant and homozygous recessive

2. Gender in humans is determined by
    a. egg cells
    b. meiosis
    c. chromosomes
    d. sperm cells

3. Which of the following is an example of environmental influence on development?
    a. Low oxygen in the womb leads to lower intelligence
    b. Music played when the mother is pregnant leads to children who love music
    c. Raising a boy as a girl leads to an effeminate boy
    d. Working out leads to bigger muscles

Use the following diagram to answer the next question.



4. The graph above could represent the distribution of all of the following traits in humans except.
    a. height
    b. sex
    c. skin color
    d. foot size

5. The greater the chance that a break occurs between linked genes, the
    a. closer the genes are on the chromosome
    b. greater the distance between genes
    c. less likely it is that there will be recombinations
    d. less potential diversity of the parents

6. What is the correct way to write out the scientific name for the human species?
    a. Homo Erectus
    b. *Homo Erectus*
    c. Homo erectus
    d. *Homo erectus*

Color blindness is an X-linked recessive trait. C = normal and C = color-blind. Use this information to answer the next five questions.

7. Which parental genotypes would result in children who are all normal-vision daughters and all color-blind sons?
   a. X^BX^b and X^bY c. X^BX^b and X^BY
   b. $X^bX^b$and X^bY d. X^bX^b and X^BY

8 If the allele for color blindness is located on the X chromosome, transmission to a male can be
   a. from dad c. from mom and dad
   b. from mom d. from neither parent, it's from a DNA replication mistake

9. X-inactivation is essential because
   a. it gives a chance for the Y chromosome to be expressed
   b. it prevents mutations from occurring
   c. only one X chromosome is expressed
   d. there aren't enough proteins to translate genes on the X chromosome

10. Nondisjunction is
   a. when chromosomes fail to separate during meiosis
   b. when chromosomes fail to match up with their homologs
   c. when chromosomes fail to separate during mitosis
   d. when tetrads fail to separate during meiosis

How many Barr bodies would be expected in the cells of the following?
   a. 0 b. 1 c. 2 d. 4

11. _____ Normal human male

12. _____ XO female

13. _____ XXX female

14. _____ XXY male

15. Whose gametes determine whether or not a boy will be color blind?
   a. the father c. the mother
   b. mostly dad, sometimes mom d. neither

Hemophilia is a recessive X-linked trait. A normal woman who's father was a hemophiliac marries a normal man.

16. What is the probablility that their daughters will have hemophilia?
   a. 0% c. 50%
   b. 25% d. 100%

17. What is the probability that their first child will have hemophilia?
   a. 0% c. 50%
   b. 25% d. 100%

18. What is the probability that their first son will have hemophilia?
    a. 0% c. 50%
    b. 25% d. 100%

19. The disease known as Down's syndrome is caused by
    a. an extra chromosome c. a missing autosome
    b. a missing chromosome d. a missing sex chromosome

Use the following key to answer the next six questions

KEY: a. Calvin Bridges
b. Mary Lyon
c. Walter Sutton
d. Thomas Morgan

20. _____ Developed the hypothesis which is now known as the chromosome theory.

21. _____ Worked with *Drosophilia*.

22. _____ Recognized the difference between male and female genomes

23. _____ Explained the difference between male and female cells

24. _____ Redefined the study of genetics

25. _____ Was the first to locate the chromosomal location of a gene

26. A father could pass dominant genes located on the X chromosome to
    a. all of his daughters c. half of his daughters
    b. all of his sons d. none of his kids

27. Crossing over ensures that
    a. chromosomes are duplicated only after the first meiotic division
    b. the two parents' genes are mixed in homologous pairs
    c. mutations do not occur in dad's genes which are passed into chromatids
    d. mutations in mom's genes are only sent to the polar bodies

Use the following diagram to answer the following six questions. Identify each statement as true (T) or false (F).

28. _____The chromosomes in the parent cell are homolgous.

29. _____ Nondisjunction must occur in order for gamete #4 to be produced.

30. _____ All the gametes show the parent's combination of genes.

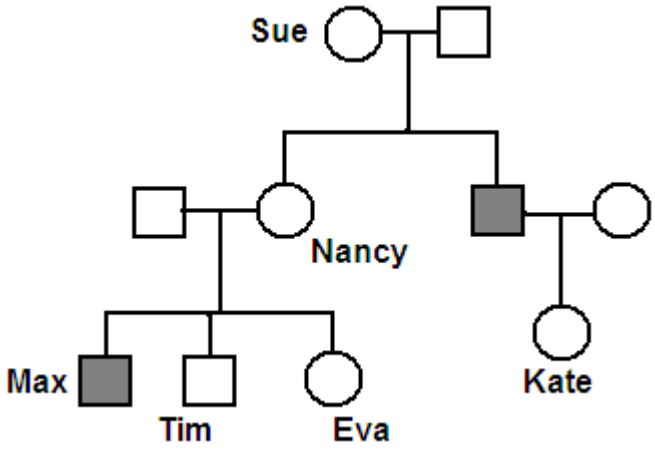
31. _____ Crossing-over occurred in the production of gametes 1 and 4.

32. _____ If gamete #3 fused with one like gamete #4, the phenotype of the offspring would be different from the parental phenotype.

In humans, individuals can end up with abnormal numbers of chromosomes. For example, XO = usually sterile female; XXX = female with a low fertility rate; XXY = tall and sexually underdeveloped male; XX = normal female; and XY = normal male

33. What is responsible for the odd number of chromosomes?
    a. gene linkage
    b. nondisjunction
    c. high hormone levels
    d. meiosis

34. Considering the above information, what conclusion can be drawn from studies of these disorders of chromosome number?
    a. The number of X chromosomes determines the child's sex.
    b. The presence of a Y chromosome determines sex in humans.
    c. The two X chromosomes are necessary to produce females.
    d. The Y chromosome does not carry genetic information.



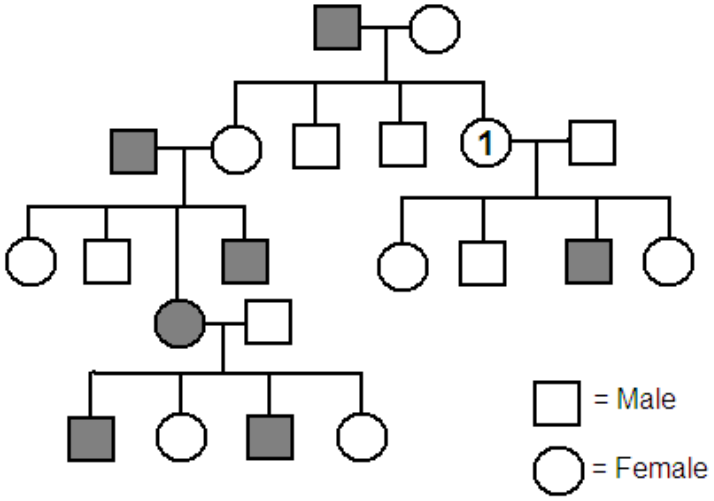
A disorder is X-linked recessive. The shaded figures in the above pedigree mark individuals who express the trait. B = normal, and b = disorder. Use this drawing and information to answer the next three questions.

35. What is Sue's genotype?
    a. X^BX^B c. X^bY
    b. X^bX^b d. X^BX^b

36. What is Nancy's genotype?
    a. X^BX^B c. X^bY
    b. X^bX^b d. X^BX^b

37. What is Kate's genotype?
    a. X^BX^B c. X^bY
    b. X^bX^b d. X^BX^b

Use the following pedigree and key to answer the next four questions.



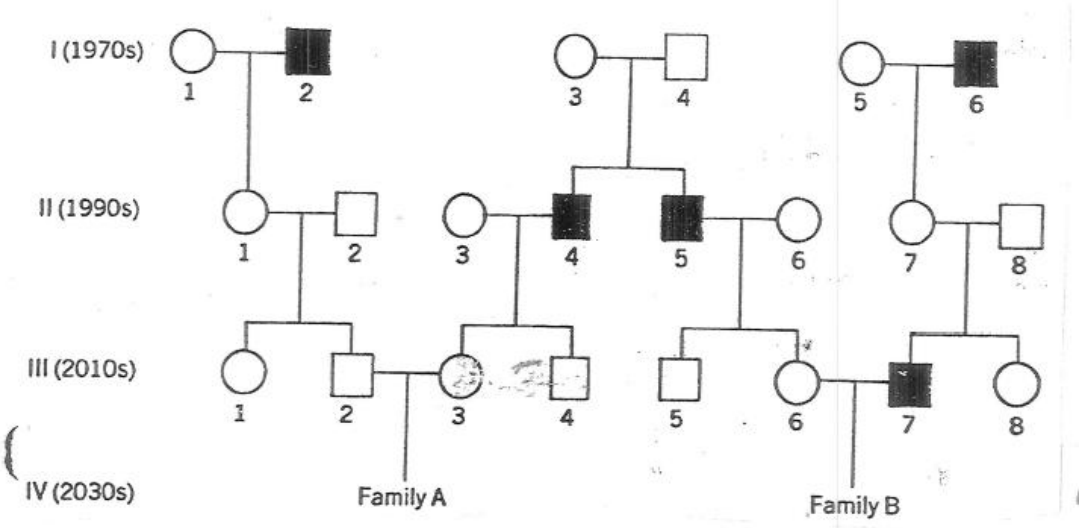
KEY: a. supported by the data
b. not supported by the data
c. not related to the data

38. _____ The genotype of every individual is clear
39. _____ Scaly skin in females must be inherited through both parents
40. _____ Person #1 is homozygous
41. _____ The trait for scaly skin is closely associated with the sex of the individuals
42. _____ The gene for normal skin is dominant to the gene for scaly skin.

Essay

What does crossing over have to do with diversity?

What is the most likely mode of inheritance of this trait? How did you come to this conclusion? Are there any other possible modes of inheritance? Are there any modes of inheritance which can definitely be crossed of the list?



Appendix C2 – AE Genetics II

AE Genetics II.Chromosomal Genetics

Day 1:

Review previous unit
Lecture: Chromosome Theory

Day 2:

Lecture: Karyotypes
"Karyotyping"* activity

Day 3:

Lecture: Gender, how meiosis is related

Day 4:

Lecture: Non-disjunction
"Sex-Linked Traits"* worksheet
Selected problems from the "Sex-Linked Inhertiance"* worksheet

Day 5:

Lecture: Sex-linked traits and linked genes
Genetic counseling demo

Day 6:

Dog pedigree
Lecture: Pedigrees
"Learning from Pedigrees"* handout
Pedigree practice packet (hw)

Day 7: (long)

Colorblindness demo: test members of the class and discuss
"A Trait in Human Inheritance"* lab

Day 7:

Review packet problems, review lectures
"Intersexual"* video

Day 8:

Presentation genetic diseases
Bioethics activity:
"Can we help our child?"*
"What will happen to my baby?"*

Day 9:

"Colorblindess"* worksheet
Practice problems

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Day 10:

Presentations on disease reports
Review for test, practice problems

Day 12:

Unit Test

Genetics II Lecture Notes (Ch 8)

Genetics isn't always as straightforward as Mendelian genetics…because he didn't know about chromosomes

CHROMOSOME THEORY- ***homologous chromosomes contain homologous alleles***

- Mendel: knew how alleles moved around
- **Walter Sutton** (1902)
    - Noticed that homologous chromosomes separated during meiosis (1 to each sperm/egg)
    - Offspring got one homologous chromosome from each parent at fertilization
    - Hypothesized/realized that homologous chromosomes each had one allele for a trait (each has one allele, so you get one allele from each parent)

        - linked movement of chromosomes during meiosis with Mendel's laws
        - Mendel: looked at input/output
        - Sutton: looked at how it moved in the middle

Once scientists understood that alleles were carried on homologous chromosomes (Chromosome Theory), they could learn even more about how inheritance/ chromosomes/genetic material affect us

- **Fruit flies** are often used for genetic research
    - small and easy to care for
    - easy/quick to breed
    - short lifespan
    - many offspring
    - chromosomes are easy to observe (large and only 4 pairs)

Scientists actually look at the chromosomes to learn more about genetics

KARYOTYPES ***a way to study the physical side of genetic***

- Chromosomes are condensed in mitosis, so scientists take pictures to observe instead of living samples
- **Karyotpe:** pictures of chromosomes cut out and arranged in pairs by size, shape, and content (homologous pairs)

What can we learn from karyotypes?

SEX DETERMINATION – *X and Y chromosomes*

- **Thomas Hunt Morgan** (1910's)
- Morgan noticed that for all *Drosophilia*
  -females*:* 4 pr homologous
  - males: 3 pr homologous, 1 pr different
    1 like fourth pr in female
    1 smaller, different shaped one
- **Sex chromosomes:** X & Y chromosomes
  X = longer one, in both sexes, all you see in females
  Y = shorter, in all males, only in males
- Sex chromosomes explain 50/50 chance of having a boy or girl
- **Autosomes:** non-sex chromosomes
  - 22 in humans

The largest scale genetic problem is when the number of chromosomes is wrong

NONDISJUNCTION ***when chromosomes don't split***

- **Calvin Bridges** while working with flies

- **Nondisjunction:** when chromosomes do not separate correctly in meiosis
  *Too many chromosomes
  * Too few chromosomes
  ***trisomy:** 3 chromosomes
  ***monosomy:** only 1

  *trisomy usually occurs in smaller chromosomes
  -big chromosomes have so much important stuff that you'd die without them
  -monosomy of autosomes is usually lethal

  *often happens in gamete before fertilization

SEX-LINKED TRAITS

- 1910, Morgan was studying fruit flies and noticed a male with white eyes, assumed that white eyes were recessive since it was rare
- Basic pure-bred cross yields all red in F1
- F2 – still 3:1
  3470:782
  Red: 2459 female
  1011 male
  White: 782 **males**

- All the white-eyed were **male!**
  → **white eye color must be linked to being male**
  → white eye color gene must be found on only the X chromosome, and it's recessive

- **Sex-linked Trait:** trait that is only found on one sex chromosome

P X^RX^R x X^rY

F1 X^RX^r x X^RY

F2 X^RX^ror X^RX^R x X^RY or X^rY

The location of alleles on chromosomes plays a large role in the relationships between how different traits are inherited. Scientists study allele location chromosomes by observing karyotypes and pedigrees.

PEDIGREES

- **Pedigree =** genetic family tree
- Show symbols
- *Observed* and not *expected*

1. Dominant vs. Recessive

Once scientists can see where alleles are located, they can hypothesize how some traits can be inherited together in progeny

Name:_____ Date _____

Chapter 8: Genetics II

WORDS TO KNOW

Chromosome Theory

Karyotypes

Pedigrees

X and Y chromosomes

Autosomes

Crossing over

Environmental influence

SCIENTISTS

Sutton

Calvin Bridges

Thomas Hunt Morgan

PATTERNS OF INHERITANCE

Nondisjunction

Monosomy

Trisomy

Sex-linked trait

Linked Genes

Polygenetic trait

Name: _____ Date:_____ Block:_____

AE Biology Genetics II Quiz (25 pts)

For #s 1-10, write the letter of the description that* best *matches the term or phrase.

_____1. Anencephaly	**A. homozygous recessive**
_____2. Calvin Bridges	**B. has two of the same alleles (word)**
_____3. Chromosome Theory	**C. gamete formation**
_____4. Downs Sydrome	**D. the alleles an individual carries**
_____5. Hurler's Disease	**E. heterozygous**
_____6. Karyotypes	**F. can cover other traits**
_____7. Nondisjunction	**G. how a trait is expressed in an individual**
_____8. Pedigree	**H. study of inheritance**
_____9. Sex-linked	**I. chromosomes line up here during metaphase**
_____10. Sutton	**J. genes being passed down**

For #s 11-13, fill in the blanks using words from the following word bank.

Autosomes Fruit Flies Pea Plant Sexosomes Trisomy
Disomy Monosomy Sex Chromosomes Snap dragons

11. The X and Y chromosomes are called _____. All other chromosomes are called _____.

12. Two types of nondijunction are _____ and _____.

13. An organism that is often used in genetic research is the _____.

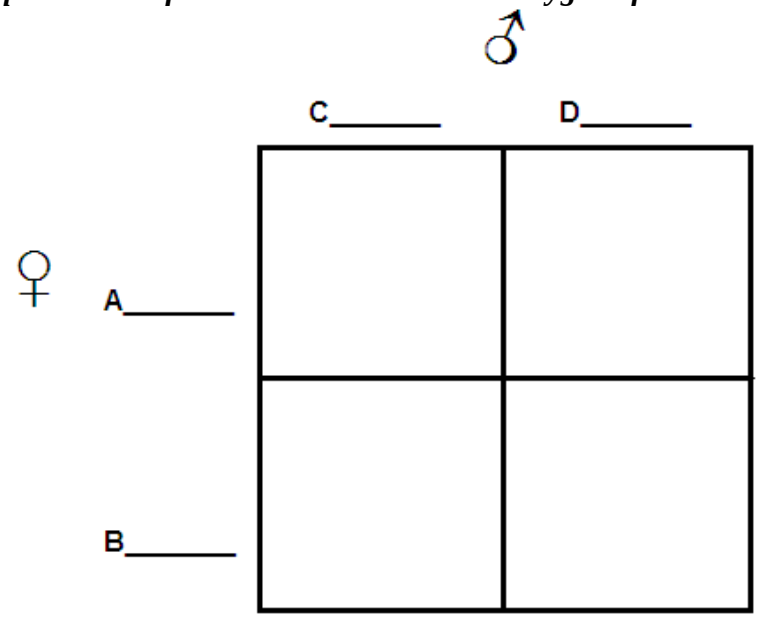
14. What are two advantages to using the organism in question #13 for genetic research?

Hemophilia is an X-linked recessive trait (X^h), and having normal clotting blood is dominant (X^H).

15. The *genotype* of a heterozygous female would be _____.

16. The *genotype* of a hemophiliac male would be _____.

Fill in the Punnett square below for a cross between a heterozygous female and a hemophiliac male.



17. What are the four possible *phenotypes* of the offspring? (Include their genders)

18. What was the difference between Mendel's approach to studying genetics and Sutton's approach?

Name:_____ Date:_____

AE Biology Genetics II Test (100 pts)

Matching

Use the keys to answer the questions that follow them.

KEY: a. Calvin Bridges
b. Mendel
c. Sutton
d. Thomas Hunt Morgan

1._____Completely revamped genetics
2._____Developed the Chromosome Theory
3._____Discovered nondisjunction
4._____Discovered sex chromosomes
5._____Founded genetics (now it's part of his nickname)
6._____Noticed that alleles split evenly during meiosis
7._____Noticed that chromosomes split evenly during meiosis
8._____Studied the eye color of flies
9._____Took a mathematical approach to genetics

KEY: a. Anencephaly
b. Downs Syndrome
c. Hemophilia
d. Hurler's Disease
e. Colorblindness

10._____ "The bleeding disease"
11._____ These children die by age 10.
12._____ These children never live for a whole day.
13._____ These people can live to be adults but have mental disabilities.
14._____ Trisomy of chromosome 21.
15._____ X-linked trait that is not lethal

True or False

Write T for true and F for false.

16. _____Human males can be heterozygous for a sex-linked trait.
17. _____Nondisjunction happens more often with small chromosomes.
18. _____Karyotypes need to be made from cells that are in mitosis.

Multiple Choice

Choose the best answer for each question or statement.

Which of these is true of X chromosomes?

a. All chromosomes are X chromosomes.
b. Men have no X chromosomes.
c. Men have one X chromosome from each parent.
d. Men only have one.

Nondisjunction is when

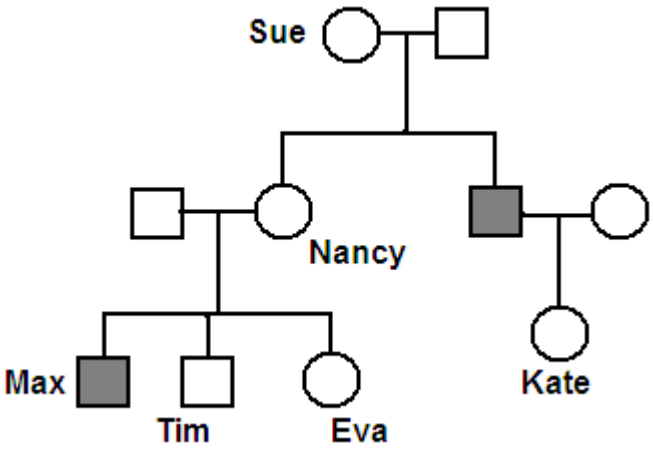
a. chromosomes fail to separate in meiosis.
b. chromosomes fail to separate in mitosis.
c. someone has too many chromosomes.
d. the chromosomes are in the wrong order

The crosses involving the white-eyed and red-eyed alleles on the X chromosome in fruit flies were a test of

a. Chromosome Theory
b. Complete dominance
c. Sex-chromosomes
d. Sex-linked traits

Which of the following about karyotypes is *not* true?

a. They are diagnostic tools.
b. They are pictures of chromosomes.
c. They show sister chromatids paired up.
d. They show the individual's gender.



The allele for big toes is X-linked recessive. The shaded figures in the above pedigree mark individuals who express the trait. B = normal, and b = disorder. Use this drawing and information to answer the next two questions.

What is Sue's genotype?

a. X^BX^B
b. X^BX^b
c. X^BY
d. X^bY

What is Max's genotype?

a. X^BX^B c. X^BY

b. X^BX^b d. X^bY

X^DX^D is an example of a

a. a carrier b. a male c. genotype d. phenotype

The consideration of important questions about the moral or ethical questions in how biology, medicine, and any biological technology should be used is called

a. bioethics b. biomorals c. biological dilemmas d. having a conscience

If the allele for color blindness is located on the X chromosome, a boy would get the allele

a. from dad. c. from mom and dad.

b. from mom. d. from neither parent, it's from a DNA mutation.

Monosomy is an example of

a. nondisjunction of autosomes.

b. nondisjunction of any chromosomes.

c. mono - an illness which is more dangerous as you get older.

d. the wrong number of chromosomes.

What is an autosome?

a. A chromosome which does not determine gender.

b. A chromosome which has no match.

c. A sex chromosome

d. The biggest chromosome.

If a human has trisomy, how many chromosomes will they have?

a. 44 b. 45 c. 46 d. 47

A carrier is someone who

a. has the allele but not the phenotype.

b. has the phenotype but not the allele.

c. has both the phenotype and the allele.

d. doesn't have the allele for the trait, it skips that generation.

Sex chromosomes were first noticed in which of these organisms?

a. Black flies b. Fruit flies c. Pea plants d. Snapdragons

Which of the following is *not* a good reason why the organism in question # would make an excellent subject for genetic study?

a. There are easy to take care of c. They're cheap

b. Their chromosomes are easy to see d. They self-pollinate

If a characteristic is sex-linked, it

a. can never occur in females. c. occurs most commonly in males

b. is always fatal d. occurs only in females

What part of a cell's life would be the best time to take a picture for a karyotype?

a. Interphase
b. Metaphase
c. When the cell's about to die
d. When the cell has just divided

Who's fault is trisomy?

a. it's a mutation from too much UV exposure (wear sunscreen!)
b. it's Dad's fault.
c. it's Mom's fault.
d. it could be either parents fault.

Which of the following is *not* true about homologous chromosomes?

Sex chromosomes never count as homologous chromosomes.
They are copies of chromosomes from one parent.

Both colorblindness and hemophilia

a. are dominant.
b. are recessive.
c. are seen in homozygous dominant people.
d. are seen only in males.

A father could pass dominant genes located on the X chromosome to

a. all of his daughters
b. all of his sons
c. half of his daughters
d. none of his kids

Sometimes people can end up with the wrong number of chromosomes. For example, XO = usually sterile female; XXX = female with a low fertility rate; and XXY = tall and sexually underdeveloped male.

What is responsible for the odd number of chromosomes?

a. high hormone levels
b. karyotype
c. nondisjunction
d. smoking

Appendix D – The "Mitosis, Meiosis, and the Cell Cycle" Unit

This appendix contains all lecture notes, overheads, worksheets, labs, and assessments used in the "Mitosis, Meiosis, and Cell Cycle" unit at the AE level.

Mitosis, Meiosis & the Cell Cycle

Lesson Plan

Day 1:

Lecture: Introduce mitosis
- PMAT
- Cytokinesis

Video of mitosis
"Interphase and Mitotic Cell Division in Animal Cells"* worksheet with me

Day 2:

Review of the day before (Video)
"Somatic Cell Division: Mitosis"* coloring worksheet
"Mitosis: Asexual Reproduction"* reading/worksheet (HW)

Day 3: (Long)

Review Mitosis, Check & Review worksheets (2 pts)
Lab: "Animal Mitosis"* Microviewer slides (30pts)
Lecture: Cell Cycle
- 5 stages
- checkpoints

Paper Cell Demo (cutting in half, multiplication)

Day 4:

Review Lab
Lecture: Cell cycle
- Review stages/checkpoints
- Cancer (pictures)

"Cell Growth and Division"* worksheet with me

Day 5:

LIBRARY MEDIA CENTER
"Cell Cycle Regulation Game"* on computers

Day 6:

Lab activity: Onion root tips under microscopes (questions on board)
Quiz review - Book questions
Lecture: Intro Meiosis

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Day 7:

Mitosis/Cell Cycle Quiz
Lecture: Meiosis
- Haploid/diploid
- Homologous chromosomes
- PMAT

Day 8:

Laser disk demo
Microscope slides activity
"Meiosis and Sexual Reproduction"* worksheet (hw)

Day 9:

"Modeling Meiosis" activity

Day 10:

Test Review: "Meiosis Review" (together)
: Worksheets/book questions
Review game

Day 11:

Unit Test

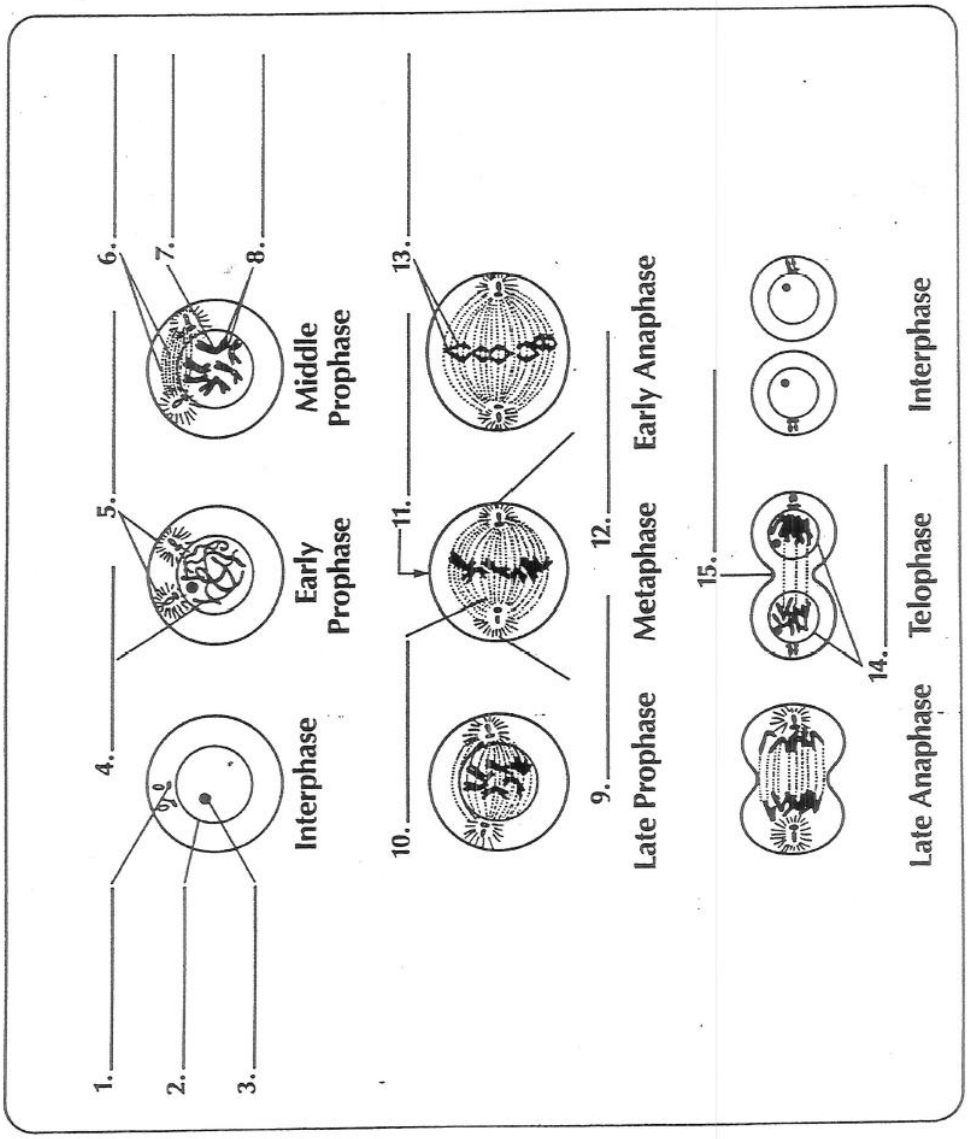
*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

NAME _____ CLASS _____ DATE _____

CHAPTER
20

OVERHEAD TRANSPARENCY MASTER

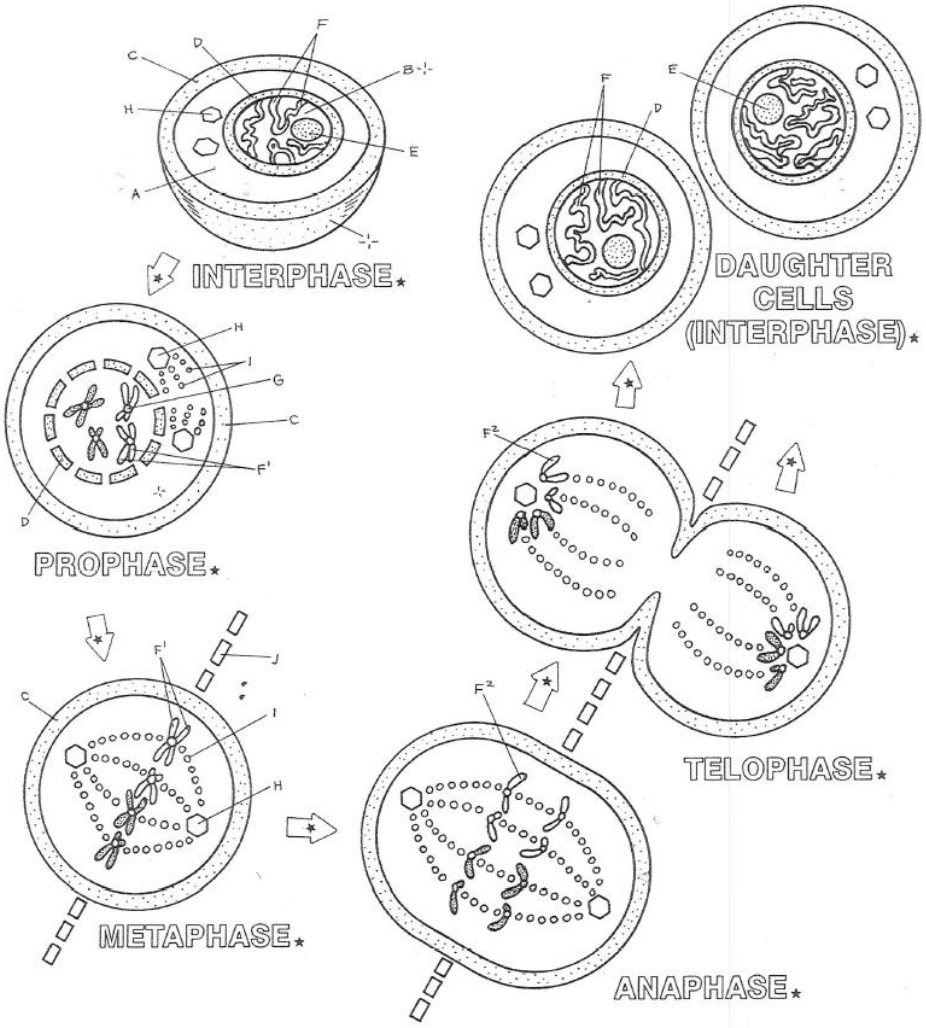
Interphase and Mitotic Cell Division in Animal Cells



SOMATIC CELL DIVISION: MITOSIS★

CYTOPLASM$_A$
NUCLEOPLASM$_{B}$
CELL MEMBRANE$_C$
NUCLEAR ENVELOPE$_D$
NUCLEOLUS$_E$
CHROMATIN$_F$

SISTER CHROMATIDS$_{F^1}$
CHROMOSOME$_{F^2}$
CENTROMERE$_G$
CENTRIOLES$_H$
MITOTIC SPINDLE FIBERS$_I$
CELL EQUATORIAL PLANE$_J$



MITOSIS ASEXUAL REPRODUCTION

Mitotic Cell Division

Functions of Mitosis

There are two basic types of reproduction --- asexual and sexual. In *asexual reproduction* there is only one parent and the genetic material of the offspring is identical to that of the parent. In *sexual reproduction* there is a combination of hereditary information from two individuals, and the offspring produced are not identical to either parent.

Mitotic cell division is an asexual process --- the two daughter cell produced are genetically identical to the parent cell. In the course of mitosis, the chromosomes of the parent double, and the cell divides in half. Each new cell contains a set of chromosomes identical to that of the parent cell.

Mitotic cell division is a means of reproduction in many one-celled organisms. In some multicellular organisms it may also be a means of reproduction, but more often it is involved only in growth, regeneration, and healing.

1. What is the basic difference between asexual and sexual reproduction?

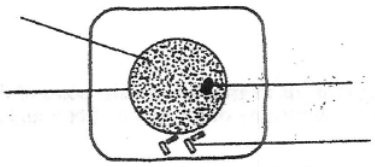
Mitosis in Animal Cells

The process of mitosis is described as occurring in stages or *phases*....

Interphase

Interphase is the stage between successive mitotic cell divisions. During this period, the chromosomes, which are within the nucleus, are in the form of a fine network of threads called *chromatin*.. The nucleus is surrounded by a mebrane, and contains one or more nucleoli. Outside the nucleus is a small region called the *centrosome*, which contains a pair of centrioles. Toward the end of interphase the chromosomes double, or *replicate*. The centrioles also double.

2. Label the structures indicated in the diagram below.



3. In what form are the chromosomes during interphase?

4. What happens to the chromosomes during interphase

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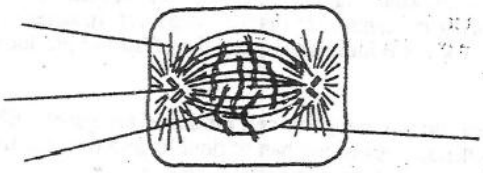
Prophase

At the beginning of prophase the pairs of centrioles separate and move to opposite poles of the cell. Spindle fibers form, connecting the pairs of centrioles. Astral rays radiate from each centriole. The chromosmes shorten and thicken. Each pair of identical chromosomes is connected at the centromere. Each strand of the pair is called a chromatid. The chromatids of a chromosome pair are attached by spindle fibers to opposite poles. One chromatid of a pair is attached to one pole and its sister chromatid is attached to the opposite pole. The nuclear membrane and nucleolei disappear.

5. Label the structures indicated in the diagram below.



6. What happens to the chromosomes during prophase?

7. What happens to the nucleus during prophase?

8. The fibers that form between the opposite pairs of centrioles are called _____

Metaphase

During *metaphase*, the pairs of chromosomes line up along the cell equator, the plane midway between the two poles and at right angles to the line connecting the poles. Once they are lined up at the equator, the sister chromatids of each pair separate.

9. What happens to the chromosomes during metaphase?

Anaphase

During *anaphase*, the separated chromatids migrate to opposite poles of the cell. The actual mechanism of chromosome movement involves the shortening of the spindle fibers and an outward movement of each of the poles.

10. What happens to the chromosomes during anaphase?

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Telophase

Telophase is the final stage of mitotic cell division. The chromosomes have reached the opposite poles of the dividing cell, a nucleus forms at each end of the cell. A Nuclear memebrane forms around each new nucleus, nucleolei appear, and centrosomes appear outside each new nucleus. Within each nucleus, the chromosomes lengthen and form the fine chromatin network characterisitic of the interphase nucleus.

At the center of the cell, the cytoplasm pinches inward (the *cleavage furrow*), dividing the original cell in two. Each daughter cell contains a nucleus and approximately half the cytoplasm and organelles of the original cell

11. In the space below, make a diagram showing a cell in late telophase.

12. What happens to the chromosomes during telophase?

13. How does cytoplasmic division occur in animal cells?

Mitosis in Plant Cells

Basically, mitosis in plant cells is the same as mitosis in animal cells. However, there are structural differences in the two cell types that cause differences in the mitotic process. There are no centrosomes or centrioles in plant cells. Spindles with spindle fibers form between the two poles of the cell and between the poles and the chromosomes.

Cleavage in plant cells differs from cleavage in animal cells because of the presence of the cell wall. Instead of the cleavage furrow of animal cells, a division plate forms through the equator of the plant cell. The *division plate* is a cellulose wall that divides the cell in two.

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14. / 15. Fill in the blanks below, comparing plant and animal mitosis.

PLANT CELLS	ANIMAL CELLS
Daughter cells contain same number of chromosome as parent cell.	_____
No centriole present, spindle forms	_____
_____	Daughter cells have about half the cytoplasm of parent cell.
_____	Centrosome present.
Cytoplasmic division occurs by formation of division plate.	_____

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STUDENT WORKSHEET

FOR

MICROSLIDE™ LESSON SET 53

ANIMAL MITOSIS

STUDENT'S NAME _____ CLASS _____ DATE _____

INTRODUCTION

In this unit we will examine the process by which an animal begins to develop from a single cell. We will use the Micro-Slide-Viewer, Microslide and Text Folder.

Read and follow the directions for the use of the Micro-Slide-Viewer and the Microslide on the envelope attached to the text folder and holding the slides.

Examine each slide and study the description in the text folder. After studying each slide and the printed text, answer the question for that slide on this worksheet. If you don't know the answer, go on to the next slide and question. You may find the answer as you learn more about the subject. Draw what you see in the space provided.

a. The process of cell development described in this set is called

_____

b. The specimen studied is the egg sac of the ascaris worm. Why?

_____

_____

SLIDE 1 - THE ZYGOTE

a. This slide shows the zygote -- the fertilized egg of the ascaris. How many masses of chromatin can you see in the cell?

_____

b. Where did these masses come from? _____

_____

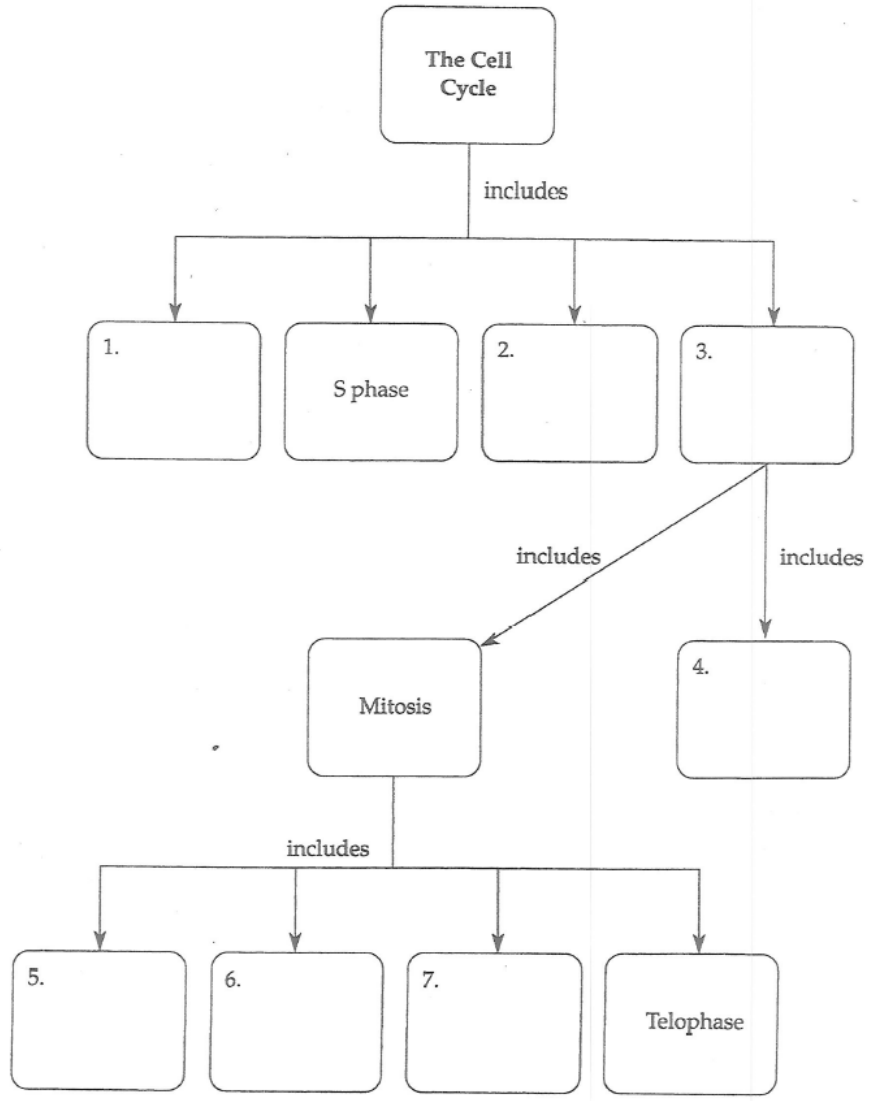
_____

c. The amount of hereditary material supplied by each parent of the ascaris is (equal) (not equal). Underline your choice.

Name _____ Class _____ Date _____

Concept Map

Using information from the chapter, complete the concept map below. If there is not enough room in the concept map to write your answers, write them on a separate sheet of paper.



Name_____Date_____Period_____

Cell Cycle Regulation Game

Please go to the following website, play the game and answer the questions below.

Site: http://nobelprize.org/educational_games/medecine/2001/~~cellcycle~~index.html

1. Describe one situation where a cell may be triggered to divide.

_____

_____

2. Which two key molecules control cell division?

_____

Now follow the directions and play the game. You must direct the cell through the cell cycle by shoosing the steps of the cell cycle in the correct order.

3. List one error that may occur in a cell if the cell cycle is not carried out properly.

_____

_____

4. According to the activity, what is a tumor?

_____

Watch the film

5. What stage of the cell cycle does it show?

_____

THE BIOLOGY PROJECT • CELL BIOLOGY

Online Onion Root Tips

Determining time spent in different phases of the cell cycle

The assignment

In this activity, you will be presented with cells from the tip of an onion root. You will classify each cell based on what phase it is in. At the end you will count up the cells found in each phase and use those numbers to predict how much time a dividing cell spends in each phase. You can base your calculation on a total cell cycle of 24 hours.

[redacted]. You can enter data in this table as you go along, or at the end of the activity.

	Interphase	Prophase	Metaphase	Anaphase	Telophase	Total
number of cells						36
percent of cells						100%

◀ PREVIOUS NEXT ▶

ONLINE ONION ROOT TIPS | CELL BIOLOGY | VOCABULARY | THE BIOLOGY PROJECT

The Biology Project
University of Arizona
January 9, 2003
Contact the Development Team

http://www.biology.arizona.edu

Go to the website listed below and do the activity explained above.
Enjoy! ☺

Go to this website

http://www.biology.arizona.edu/cell_bio/activities/cell_cycle/assignment.html

2/13/03

Name_____Date_____Period_____

Cell Cycle Regulation Game

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Now follow the directions and play the game. You must direct the cell through the cell cycle by shoosing the steps of the cell cycle in the correct order.

3. List one error that may occur in a cell if the cell cycle is not carried out properly.

_____

_____

4. According to the activity, what is a tumor?

_____

Watch the film

5. What stage of the cell cycle does it show?

_____

Microscope Slides

- 5 microscopes, each with slides of plant cells in mitosis, different stage at each scope
- Interphase + PMAT
- Onion root tips work well
- Use arrow in eyepiece to indicate which cell

- Students look at each # microscope, and answer questions written on board

QUESTIONS

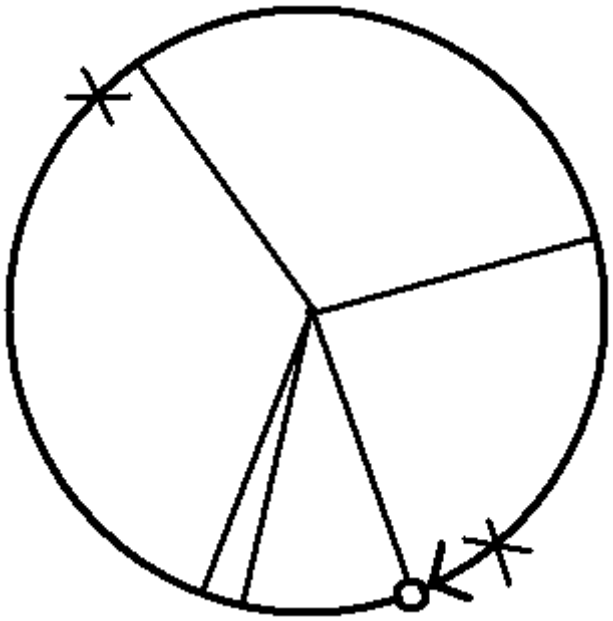
1. Draw what you see in the cell pointed out
2. Label the parts of the cell that you can see
3. What'sgoing on in his cell? (Describe what you see
4. Identify the stage. How do you know that's the stage?

Name: _____ Date:_____ Block:_____

AE Biology Mitosis & Cell Cycle Quiz (30 pts)

1-7. Label the diagram below with the following terms:

S phase	**Mitosis**
G_1 phase	**Cytokinesis**
G_2 phase	**G_2 checkpoint**
G_1 checkpoint	



8. The diagram above represents the _____.

9. The part of the cell cycle where the cell is not dividing is called _____.

10. Some cells spend their entire lifespan in the _____ phase.

11. _____ is a disease caused by uncontrolled cell division.

12. Give two possible cases of the above disease.

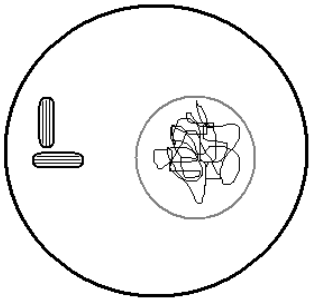
13-20. Label and draw the four stages in cell division in the circles below. Include and label the following structures:

Centrioles

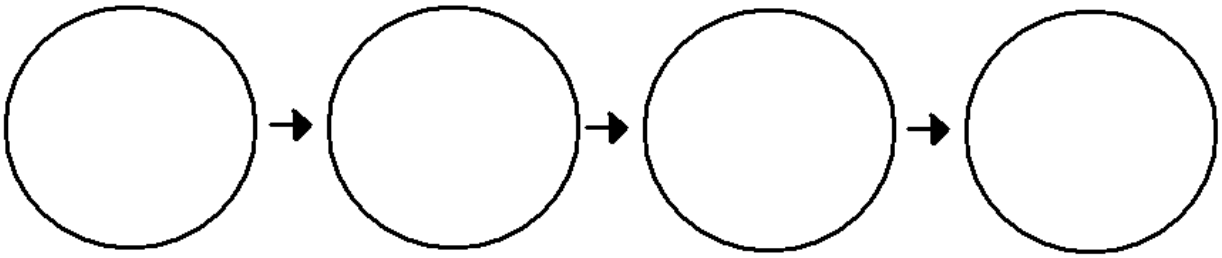
Nuclear membrane

Spindle fibers

Chromosomes



Cell during interphase



In the space provided, write the letter of the description that best matches the term or phrase.

_____21. spindle fibers	**A. chromosomes travel to poles**
_____22. cytokinesis	**B. centrioles are found here**
_____23. nuclear membrane	**C. hold sister chromatids together**
_____24. equatorial plate	**D. composed of microtubules**
_____25. DNA replication	**E. are split apart during mitosis**
_____26. centromeres	**F. cellular membrane pinches in and two new cells are**
_____27. cytoplasm	**formed**
_____28. poles	**G. centrioles travel here during prophase**
_____29. anaphase	**H. dissolves during prophase**
_____30. chromosomes	**I. chromosomes line up here during metaphase**
	J. occurs during interphase

MEIOSIS and SEXUAL REPRODUCTION

MEIOTIC CELL DIVISION and GAMETOGENESIS

The cells of most protists and all green plants and animals have a characterisitic number of chromosomes. The full characterisitic number of chromosomes in a cell is called the *diploid*, or 2n number. It is called the 2n number because there are two of each kind of chromosome-- one from each parent. Such chromosome pairs are called *homologous chromosomes*. Homologous chromosomes are similar in shape and function, but they are not identical. Half the characterisitic number of chromosomes is called the *haploid*, or n number. In a haploid nucleus there is only one of each type of chromosome, -- that is , there is only one of each pair of homologous chromosome.

At some point in all forms of sexual reproduction, there is a union of two sex cell, or *gametes*. The cell formed as a result of this union is called the zygote. The zygote will have double the number of chromosomes of each gamete. *Meiotic cell division* is the process by which the number of chromosomes is reduced by one-half. Depending on the species, meiotic cell division occurs either during the formation of gametes or in the newly formed zygote.

1. The 2n number of chromosomes is also called the _____ number.

2. The n number of chromosomes is also called the _____ number.

3. Sexual reproduction involves specialized sex cells or _____.

4. What is accomplished by meiotic cell division?

MEIOTIC CELL DIVISION

first meiotic division

In mitotic cell division, the chromosomes replicate ance and the cell divides once. The chromosomes content of the two daughter cells is identical to that of the parent cell. In meiotic cell division, the chromosomes replicate once, but there are two cell divisions. Each of the four cells produced has half the number of chromosomes of the parent cell.

During prophase of the first meiotic division, pairs of homologous chromosomes join together at their centromeres, forming a structure called a *tetrad* (since it consists of four chromatids -- two in each chromosome). This process is called *synapsis*. It is the tetrads that move to the equator of the cell at metaphase. Then, during anaphase, the tetrads split apart into original double chromosomes. One double chromosome of the pair moves to one pole of the dividing cell, while the homologous double chromosome moves to the other pole. As a result, when the cell divides, each daughter cell receives only one chromosome from each homologous pair. It is thus half as many chromosomes as the parent cell had.

5. What is synapsis?

6. How does the arrangement of chromosomes at metaphase differ in mitotic cell division and the first meiotic cell division?

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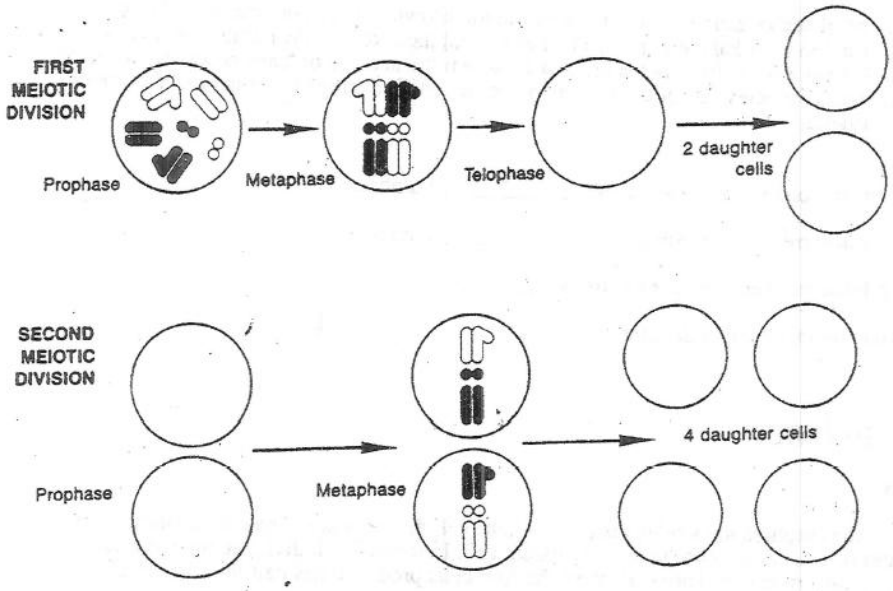
:cond meiotic division

he second meiotic cell division follows the first almost immediately. It is similar to a mitotic divsion. In oth of the cells produced by the first division, the chromosomes (in the form of chromatid pairs) line up at ıe metaphase plate. The chromatids separate, and identical chromatids move to opposite poles of the cell. he cell divides in two. Each daughter cell receives a haploid set of chromosomes.

he diagram below represents meiotic cell division in an organims with six chromosomes. Fill in the proper hromosome arrangements in the blank circles.



Gametogenesis

Gametogenesis is the formation of specialized sex cells or gameter. There is generally a small, motile gamete called a *sperm* and a much larger, nonmotile female gamete call an *egg*.

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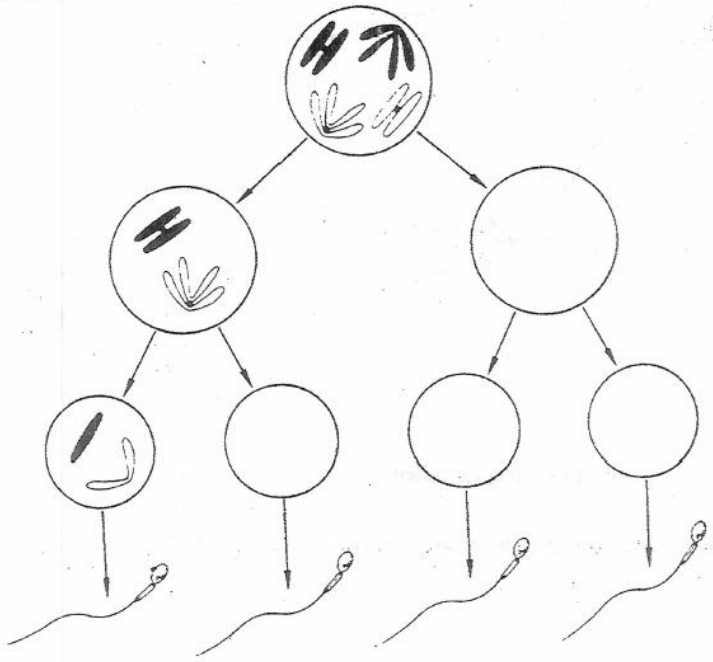
spermatogenesis

Spermatogenesis, the production of sperm, occurs in the male gonads-- the testes. In some animals, sperm develop only during specific mating seasons. In others, including humans, sperm are produced all year long.

The sperm develop from unspecialized cell called *spermatogonia*. Spermatogenesis begins with the formation of *primary spermatocytes* from spermatogonia. The first meiotic division of the primary spermatocytes produces two *secondary spermatocytes*. the second meiotic division of the two secondary spermatocytes produces four *spermatids*. the spermatids develop into mature sperm, but there is no further cell division.

Sperm, which are produced in great numbers, are very small. They consist of a *head*, which contains a haploid nucleus and a *flagellum*, which serves as a means of locomotion. At the junction of the head and the flagellum is a *collar* containing many mitochondria. ATP produced in the mitochondria serves as a source of energy for the beating flagellum.

In the diagram below, label the following: primary spermatocyte, secondary spermatocyte, spermatid and mature sperm. Fill in the missing chromosomes in the blank circles below and indicate where the first and second meiotic divisions occur.



Label the parts indicated on the diagram of a sperm below.

122.

Name:_____ Date:_____ Block:___

Modeling Meiosis

In this activity you will create a model of meiosis. Make sure that you have six pieces of red pipe cleaner, six pieces of green pipe cleaner, six beads, and a long piece of yarn. Use different colors to indicate which parent the genetic material comes from. Use your notes and model to answer the questions.

Most of the cells in an organism are somatic c ells. That is to say, they are non-reproductive cells with the diploid (2n) number of chromosomes. However, the body produces some cells which have the haploid number (n) of chromosomes. These are reproductive cells, or gametes.

1. Create a model of an egg and sperm cell of two organisms whose haploid number is three. Draw a picture of your models below.

For offspring to be formed, male and female gametes must combine to form a zygote. During fertilization the chromosomes from male reproductive cells make their way into the egg cell. This zygote will have two copies of each type of chromosome: one from the father, and one from the mother. The pairs are called homologous chromosomes. A pair of homologous chromosomes will be similar in size, shape, and genetic content. The haploid number indicates the number of pairs of homologous chromosomes which an organism can have, and the diploid number is the total number of chromosomes in a fertilized zygote.

2. Use your model to demonstrate fertilization.

a. What is fertilization? What does fertilization form?

b. What does 2n signify? What would the 2n number be in this organism?

c. Draw a picture of your model of a fertilized egg below. Color code

As the zygote moves through the cell cycle, a copy will be made of each chromosome. This DNA replication occurs during S phase. By the beginning of meiosis I, there will be four copies of each type of chromosome (two originals from each parent + two new copies). The new copies will pair up with the original chromosomes from each parent. During metaphase I, these pairs of chromosomes will line up along the equatorial plane of the cell. These sets of four chromosomes are called tetrads. During anaphase I, the tetrads will be separated so that each cell gets a set of either the mother or fathers chromosomes.

3. Demonstrate S phase and the stages of meiosis I with your model.

a. What is a tetrad?

b. Draw your model of metaphase I below.

b. Draw your model of the two new cells formed below.

c. Are all of these cells identical?

You should now have two cells, each with pairs of chromosomes. Each pair of chromosomes in these new cells should be a set of two copies of one parent's chromosome (so each pair should only be one color. For example, one cell may have two pairs of reds and one pair greens, while the other has two pairs of greens and one pair of reds.)

Now you will model meiosis II. Note that in between meiosis I and II the cells *will not* go through S phase, so their chromosome number will not double. This is one of the major differences between a *meiotic* cell and a *mitotic* cell. By the end of meiosis II you will have four cells, each with the haploid number. During metaphase II the pairs of chromosomes will line up along the equatorial plane. During anaphase II each pair of identical chromosomes will be separated, and during telophase II four new cells will begin to form, each with three chromosomes.

4. Demonstrate meiosis II with your model.

a. Are any of the three chromosomes in your new four cells homologous chromosomes? Why or why not?

b. Draw your model of metaphase II.

c. Draw the new cells formed in meiosis II.

d. Are all four of your new cells identical?

Meiosis vs. Mitosis - *Fill in the chart below which compares meiosis to mitosis*

Meiosis	Mitosis

.

Name:_____ **Date:**_____ **Block:**___

AE Biology Mitosis/Meiosis Review

Fill in the blanks, and draw the genetic material in the cells on the right

1. **Gametes** = _____

    - _____= **haploid**
      = # types chromosomes
      = 23 in humans

2. **_____ = fertilized egg**

    - **2n** = _____
      = # total chromosomes
      = 46 in humans

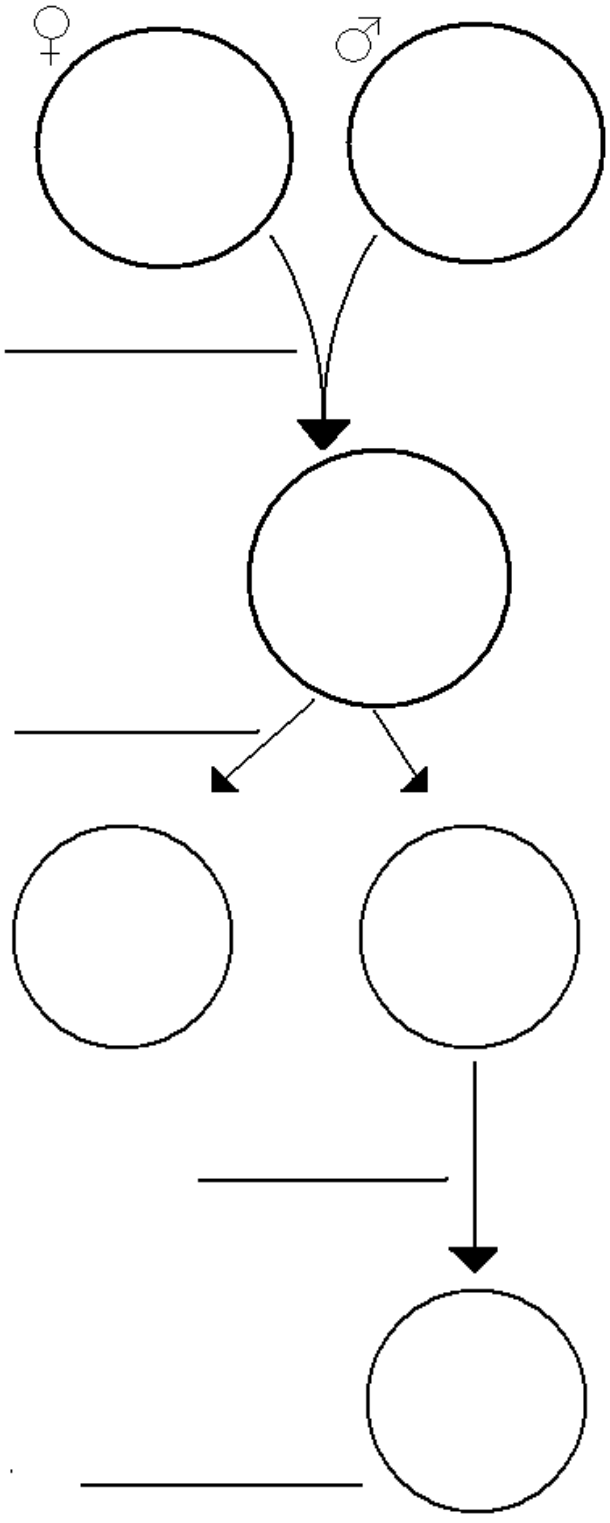
3. **Mitosis** = _____

    - P_____
    - M_____
    - A_____
    - T_____
    - Cytokinesis =

4. **DNA replication** occurs during the

   _____ of **interphase**

5. _____ **Cell** =
   non-reproductive body cell



Name:_____ Date:_____

AE Biology Cell Cycle, Mitosis & Meiosis Test (100 pts)

Matching

Match each term with its best description.

1. _____ Cells that are not dividing
2. _____ Identical copies of one parent's chromosome
3. _____ Fertilized egg cell.
4. _____ 23 in humans
5. _____ Example: sperm cell
6. _____ Are similar in size and shape
7. _____ Two pairs of homologous chromosomes
8. _____ 46 in humans

a. diploid
b. gametes
c. haploid
d. homologous chromosomes
e. sister chromatids
f. somatic
g. tetrad
h. zygote

Fill-Ins

Use the words below to fill in the blanks in the following questions.

anaphase	G_1 phase	microtubules	prophase
centrioles	G_2 phase	mitosis	S phase
centromeres	interphase	nuclear membrane	sister chromatids
cytokinesis	meiosis	plasma membrane	spindle fibers
equator	metaphase	poles	telophase

9. Spindle fibers are made of _____.
10. DNA replication occurs during _____.
11. The parts of the cell cycle in which the cell is not dividing are all a part of _____.
12. During metaphase, chromosomes are attached to their matches by proteins called _____.
13. Some cells spend their entire lives in _____.
14. The cell splits into two new daughter cells during _____.

****

The process of cell division is called (15)_____. At the beginning of (16)_____the centrioles move to opposite (17)_____of the cell, and the (18)_____disintegrates. (19)_____is when pairs of chromosomes line up along the cell's (20)_____. (21)_____attach to chromosomes during this phase. During (22)_____the chromosomes are pulled apart, and they arrive to their destination during (23)_____.

Multiple Choice

Choose the best answer for each question or statement.

24. The cell cycle is
    a. meiosis I + meiosis II.
    b. the cell's entire life
    c. the sequence of events between mitotic divisions.
    d. how a cell divides.

25. The process of cell division is called
    a. cytokinesis
    b. meiosis
    c. mitosis
    d. telophase

26. What is it called when a cell's plasma membrane pinches into two daughter cells?
    a. cytokinesis
    b. meiosis
    c. mitosis
    d. telophase

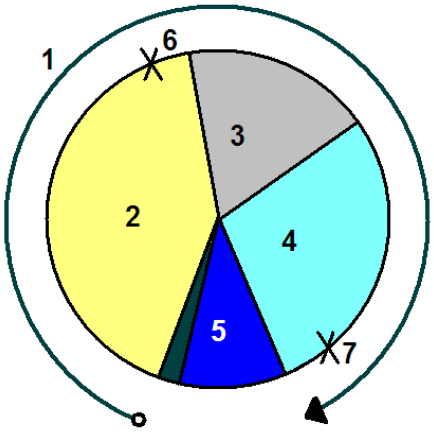
27. Sister chromosomes are
    a. completely identical
    b. from each parent
    c. only found in gametes
    d. similar in shape and size

28. Microtubules which will be needed for mitosis are produced during what phase in the cell cycle?
    a. G_1 phase
    b. G_2 phase
    c. prophase
    d. S phase

29. The best description for cancer is that it is
    a. the result of all genetic mutations
    b. when the cells skips the G_1 checkpoint
    c. when the cells skips the G_2 checkpoint
    d. when the checkpoint system in the cell cycle breaks down

30. Humans have
    a. 46 homologous chromosomes
    b. 46 sister chromosomes
    c. diploid number of 46
    d. haploid number of 46

The following four questions refer to the diagram of the cell cycle below.



31. The large arrow labeled #1 is meant to represent
    a. mitosis
    b. meiosis
    c. cytokinesis
    d. interphase

32. Some cells spend their entire life in the phase labeled
    a. #2
    b. #3
    c. #4
    d. #5

33. DNA is replicated in the phase labeled
    a. #2
    b. #3
    c. #4
    d. #5

34. In what forms are the chromosomes during interphase?
    a. DNA
    b. centromeres
    c. chromatin
    d. replication

35. Which is the best description of mitosis?
    a. division of a cell nucleus
    b. DNA replication
    c. cell growth
    d. cytokinesis

36. Polar bodies are
    a. produced during formation of male gametes
    b. produced during formation of female gametes
    c. another name for centrioles
    d. chromosomes that separate

37. The G_1 checkpoint ensures that the cell
    a. finished mitosis
    b. has enough DNA to divide
    c. has no mutations in its DNA
    d. is big enough to divide

38. Mitosis in plants differs from mitosis in animals because
    a. plant cells have fewer chromosomes
    b. plant cells have no centrioles or spindle fibers
    c. cytokinesis in plants occurs when a division plate grows
    d. plant cells have more cytoplasm

39. The cell cycle is controlled by
    a. chromosomes.
    b. spindle fibers.
    c. the nucleus.
    d. cyclin.

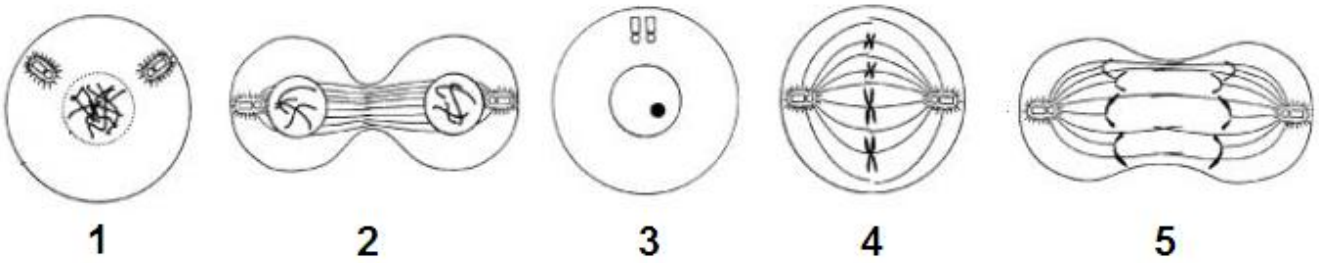
40. Similar chromosomes from each parent form
    a. diploids
    b. genes
    c. homologous chromosomes
    d. sister chromosomes

41. metaphase : anaphase ::
    a. G_1 phase : G_2 phase
    b. S phase : G_2 phase
    c. mitosis : meiosis
    d. mitosis : G_1 phase

42. Some cells spend their entire life in
    a. the G_1 phase
    b. the G_2 phase
    c. mitosis
    d. prophase

43. The stage of mitosis in which cells spend the least time is
    a. anaphase
    b. metaphase
    c. prophase
    d. telophase

The following three questions refer to the diagram below.



44. Cell #3 is in
    a. prophase
    b. metaphase
    c. interphase
    d. cytokinesis

45. In which cell are spindle fibers being formed?
    a. Cell #1
    b. Cell # 2
    c. Cell # 3
    d. Cell # 4

46. What is the correct order of these cells?
    a. 2-1-4-5-3
    b. 3-1-4-5-2
    c. 1-3-4-5-2
    d. 4-5-2-1-3

47. In humans, 23 is

a. n
b. 2n
c. the number of homologous chromosomes
d. the diploid number

48. If an organism's haploid number is 12, how many chromosomes are in one of its somatic cells?

a. 3
b. 6
c. 12
d. 24

49. The cells formed as a result of meiosis II are

a. all identical
b. not all identical
c. somatic
d. zygotes

50. The stage of mitosis which cells spend the most time in is

a. anaphase
b. metaphase
c. prophase
d. telophase

51. Meiosis I is when

a. diploid cells become haploid
b. haploid cells become diploid
c. tetrads are separated
d. the cell divides

52. Meiosis II is when

a. diploid cells become haploid
b. haploid cells become diploid
c. tetrads are separated
d. the cell divides

Appendix E – "Evidence of Evolution" Unit

This appendix contains all lecture notes, worksheets, labs, and assessments for the "Evidence of Evolution" unit at the Honors level.

Evidence of Evolution
Lesson Plan

Day 1:

Review last three units: Protein Synthesis, Mendelian Genetics, Chromosomal Genetics…link them to evolution
Explanation about the ethical/personal side of evolution (you are free to think what you want!! We're only talking about what can be studied in the lab)
Lecture: Introduction to evolution

Day 2:

Lecture: History and Natural Selection

Day 3:

Lecture: Theory of Evolution and types

Day 4:

Review lectures
Continue lecture on evolution

Day 5 (long):

OUTSIDE
"Natural Selection" pasta lab (reports due day 8)

Day 6:

Discuss lab
Review format of Lab Reports
Lecture: Introduce evidence of evolution

Day 7:

Fossil demonstration
Lecture: Fossils
Quiz (15 min)

Day 8:

"Fossil Study"* activity

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Day 9:

Review "Fossil Study"*
Lecture: Comparative anatomy
"Geologic Timescale"* and "Geologic Time"* worksheets (finish for hw)

Day 10:

Bones demonstration
"Evidence of Evolution"* activity

Day 11:

Lecture**:** Other evidence
"Amino Acid Sequence as Evidence of Evolution"* activity (finish for hw)

Day 12:

"Fossil Evidence"* video

Day 13:

Test review

Day 14:

Unit Test

*Taken from the Wachusett Regional High School Science Department Archives, February-June 2007.

Honors Biology – Evidence of Evolution

Background of Evolution (Ch. 16 & 17)

Evolution is slow, no one has witnessed it long term. Does it really happen??

1. Define concept of evolution
2. Investigate Theory of Evolution
3. Identify evidence of evolution

**Evolution is controversial, and lots of people disagree with it every step of the way. Whatever you think, it is important to understand the scientific thoughts, learning, and applications of your time period. By using the scientific method to develop theories, we can choose how/what to apply to our lives.

EVOLUTION DEFINED

Aristotle/Genesis - creation

Buffon * Lamarck -

1. Life is changing all the time
2. Life is adapting to a constantly changing environment
3.

Lamarck – aquired traits can be passed on

Smith, Charles Lyell & John Sutton – different forms of life were around at different times (geologists, looked at fossils in strata)

Malthus –

Food supply grows arithmetically
Population grows geometrically
*Life is a struggle to survive

Darwin & Wallace

A natural factor selects better-adapted individuals to survive…

* Natural Selection

NATURAL SELECTION

Population
Species
Fitness

1. Variability
2. Heritability
3. Differential Reproduction

Proof:

Kettlewell

EVOLUTION

- The overall change in a population's gene pool (microevolution)
- **Gene pool** = all alleles in population
  - Evolution doesn't occur in individuals
  - can eventually lead to change in entire species' genes
- Slow/gradual process
  - rarely seen in one lifetime
- Leads to better adaptations
- 1 trait at a time qualifies

Causes

- **Natural selection**
- **Genetic drift**
- **Catastrophe**
- **?**

THEORY OF EVOLUTION

One life-form which occurred long ago has evolved into the many present-day organisms

1. *Life originated in space and traveled to Earth*

2. *Life originated by unknown means on Earth*

3. *Life evolved from the interaction of abiotic substances with the environment*
   - easiest to test scientifically

Life = organisms

Organisms = **chemical systems** that maintain homeostasis and has continuity

CHEMICAL EVOLUTION

- Life evolved from chemicals on Earth

- **Oparin and Haldane** (1920's)
- **Heterotroph hypothesis** = the first life-froms fed on organic compounds in "organic soup" of primitive earth

1. **Supply of organic molecules**
   -need matter + energy to make them react
2. **Small molecules form polymers**
   - concentrated
   - big proteins and nucleic acids needed most
3. **polymers create self-replicating system (use organic monomers from step 1 to do the work)**

1. Supply of organic molecules

Big Bang Theory = universe was once a tiny ball which exploded 15 billion years ago. All matter is now moving away from itself. Some has gravitized into bodies which are still traveling outwards

Early Earth

- hot
- Atmosphere fromed from gases released from inner-Earth once crust cooled
- Atmosphere = N2, NH3, H, a little CO, some H2O vapor
  - no oxygen!

Stanley Miller (1950's)

- Sets up apparatus containing gases of early environment (CH4, NH3, H2O, H2) , shocked them with electricity
- After one week, some tar and red liquid
- Red liquid contained amino acids and bits of RNA!!!!
- Other scientists have found 13+ (out of 20) amino acids!
- Needs at least some methane, no oxygen, specific ratios

Space

- Australia 1969 – meteorite with 7 amino acids, 5 of them found on Earth
- Halley's comet has organic material (formaldehyde…needed for RNA)

2. Small molecules form polymers

- Need to be concentrated enough to react

Clay

- Crystal structure that attracts charged organic molecules
- Could have catalyzed reactions

- Clay has been used in labs to catalyst formation of organic polymers

3. Polymers create self-replicating system

- Which came first?
  - DNA: codes for proteins
  - Proteins: synthesize DNA

"RNA World" hypothesis

- RNA could have been produced in primitive Earth (nonbiologically and spontaneously)
- Some RNA can catalyze their own partial replication
- RNA = information plus catalyst
- Lots of work left to do….still a hypothesis

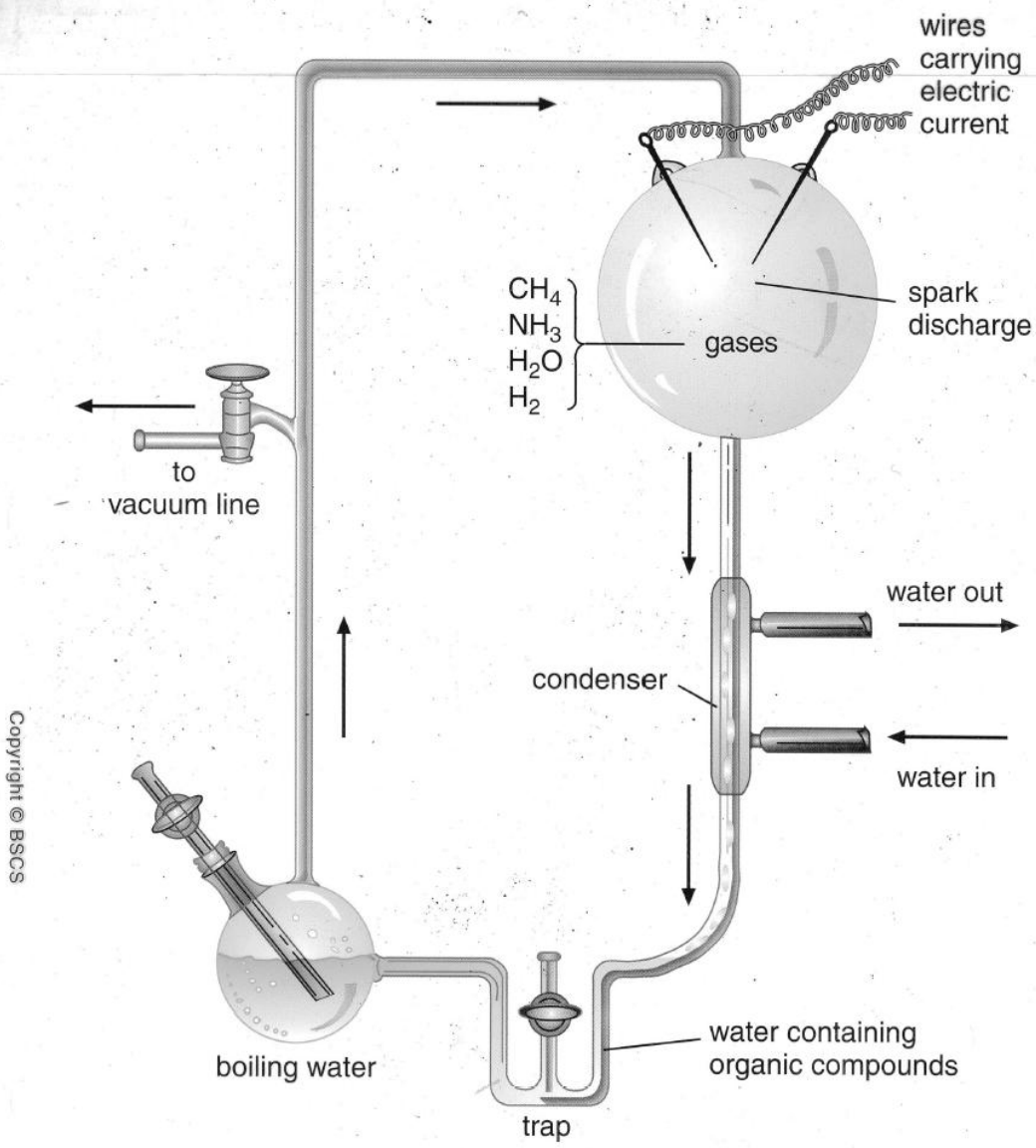
BIOLOGICAL EVOLUTION

NASA's Exobiology Program:

"'Life' is a self-sustained chemical system that is capable of undergoing Darwinian, or biological, evolution."

1. Self-reproduction
2. Mutation that can be inherited
3. Natural selection

- Began with the origin of life
- Cells? When would they have formed?



Honors Biology – Evidence of Evolution

Evidence of Evolution (Ch. 16 & 17)

Evolution occurs over a long time, especially the kind of evolution discussed in the Theory of Evolution. Scientists use the imprint (fossils). Need to know a) what they show, and b) how old are they?

EVIDENCE FOR EVOLUTION

- Fossils help scientists form timelines
  - -a type of organisms' lifespan
  - - "Theorists" try to track the entire history of life
- Can also look at living animals

- "history of life" =
  primitive single-celled → complex single-celled → mutli-celled
- Overall: complexity grows with time
  - - evidence of evolution since adaptations could come from natural selection
  - - "many organisms couldn't adapt and went extinct"
- Four things to look for:
  1. Age
  2. Homologies
  3. Biochemistry
  4. Embryology

1. Age

- Fossils help people categorize age
- First estimates of time periods were done by relative dating. Absolute dating methods say that Earth is a lot older than relative dating estimated

Relative Dating ← no! it isn't dating your cousin!

- **Law of superposition =** fossils in lower layers are older than higher layers
  - **strata** = layers in sedimentary rock
  - three types of time intervals:
    Epoch = shortest
    Period = medium
    Era = longest

- **Fossil correlation =** rocks with similar fossils are the same age

FOSSILS

- **Paleontology** = study of fossils and what they show
- **Fossil = p**reserved remains of organisms (usually plants and animals)
  - also footprints
- Often the "hard parts" such as bones and shells
  - contain Ca
  - leaves of plants and eggs are also found
- **Mineralization =** Ca (water soluble) replaced by a mineral
  1. **mold:** organism (shell, bone, etc) dissolved by water
  2. **cast:** mineral fills mold

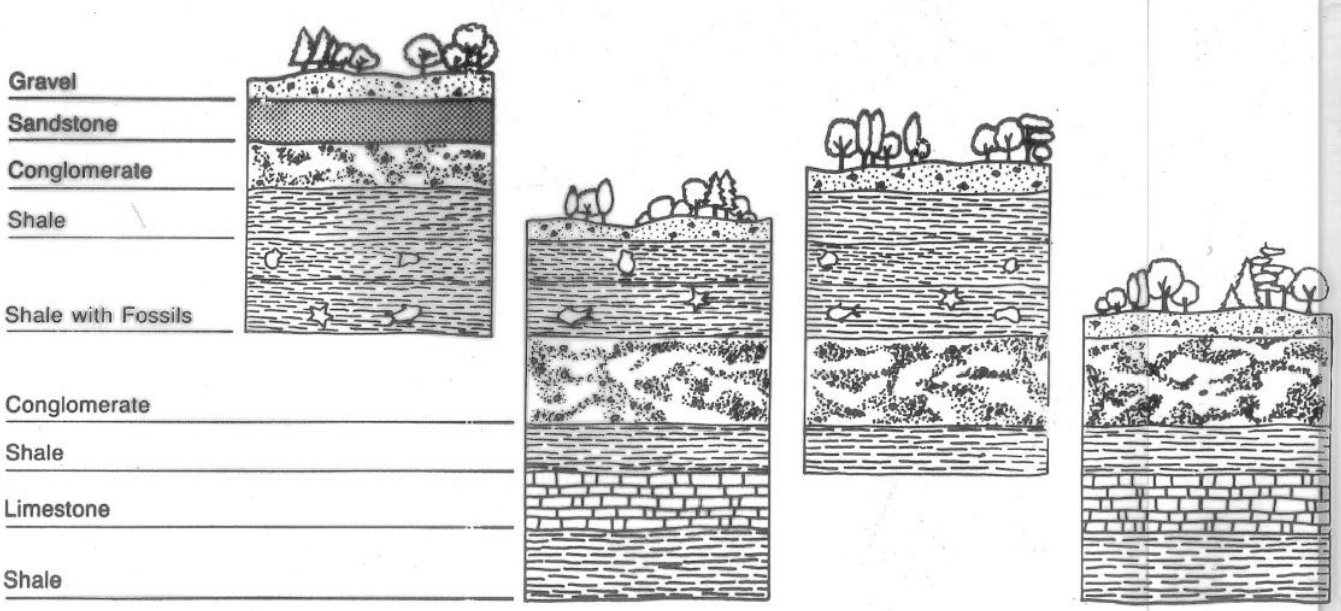
  - because water is needed for the mold, animals that are in or near water are the most typical fossils
  - found in sedimentary rock

- Types of fossils:
  - Mineralized/Sedimentary/Hard Tissue
  - Imprints
  - Ash/Volcanic
  - Soft Tissue (ice and amber)

<u>Absolute Dating</u>

- **Radiometric dating** B-block = determining age by breakdown of radioactive isotopes with specific half-lives
- **K-Ar dating** = using half-life of $K^{40} \rightarrow Ar^{40}$ (1.3 million years)
- **Carbon dating =** half-life of $C^{14} \rightarrow N^{14}$ (5,760 years), but it's only good for 50,000 years

Correlation of Rock Layers



2. Homology

- **Comparative anatomy =** comparing structure/function of organisms' anatomy and finding patterns

- Structures can be
  - **Homologous =** similar "origins" and structures
    - Ex human arms and whale flippers
  - **Analagous =** different origin but similar structure because they have the same function
- Sometimes E-block populations in a species become more diverse
  - **Divergence =** descendents of common ancestral group become more diverse over time
    - Ex. Wolves → domestic dogs

    - **Vestigial organs =** evolve to be smaller and have no function
      - Ex. Human appendix vs. pig cecum
        - Human tailbone vs. monkey tail
        - Human wisdom teeth vs.
        - Human body hair vs. monkey hair

    - **Convergence =** unrelated species with similar needs evolve to have similar structures over time
      - **Analagous structures**
        - Ex. Wings: bat, butterfly, bird,

- **Body plans** - similiarities in body functions
  - **- Mitosis, DNA, use of ATP**

3. Biochemistry

- Compare DNA sequences
- Compare amino acids in proteins

4. Embryology

- "Onotogeny"
- Compare *pre natal* developement

NATURAL SELECTION

"The sculptor of life"

BACKGROUND AND OBJECTIVES:

Since Darwin's time, natural selection has been established as the main mechanism of evolution. The basic concept is that organisms which are more fit due to longevity and a high reproductive rate will have more offspring. Over time the genes of the more fit animals will become more prevalent in the population's gene pool, thereby causing the species to evolve. Because it takes a long time for the effects of natural selection to become apparent in a population, it is also very difficult for humans to track this progress and enhance their understanding of the process. In this lab, you will model natural selection's effects on a population over time in an attempt to gain further understanding of its role in evolution. As you go along, be sure to identify predator-prey and competition relationships, and make note of each member's effect on the other.

QUESTIONS:

1. What is natural selection? What are its three tenets?

2. What are some environmental factors which a population would need to adapt to?

MATERIALS

- Various types of macaroni
- Containers (cups, beakers, etc)
- Forks, knives, and spoons
- Markers for grids (ex. Books)
- Stopwatches
- Graph paper

PROCEDURE

Each experiment will be done in groups of various sizes.

Foragers: Follow Timer's directions and cues to forage for food
Timers: Keep track of time elapsed and record times
Counters/Recorders: record other data

SITUATION #1

- All members of the class will be foragers.
- Each forager starts with one knife
- 1 day = 60 seconds
- Scatter large round shell macaroni

Each day:

- Foragers must gather at least five pieces of food to survive to the next day.
- Foragers may touch the food with only their utensil. Each piece of food must be placed back in the nest (a cup) by the end of the day.
- At timer's signal, foragers will attempt to gather food.

At the end of the day:

- Anyone who did not bring five pieces of food to their nest will die.
- Whichever forager gathered the most food may reproduce by tapping one of the dead foragers back in. Instead of the utensil this forager may have had originally, they will return with the same type of utensil as their "parent."
- All captured food will be re-scattered for the next day

At the timer's discretion, the situation will begin to change.

- A random mutation will occur, and one individual will be born with a fork.
- Later, another forager will be born with a utensil mutation. This time it will be a spoon.

Other possible changes:

- Introduction of a new type of food
- Foragers with two utensils
- Foragers with combinations of different types of utensils
- Limit to food replenished
- One type of forager begins to reproduce at a higher rate (can tap more than one person back in)
- All players who gather 8 pieces of food tap new people in
- A different variation besides eating utensils
- Something creative that the class comes up with!

SITUATION #2

- Groups of two foragers and one timer
- Each group takes 100 large round shells
- Each group sets up a grid: 5 paces x 5 paces. Use markers to mark the corners and spots along the sides.
- Foragers face away from grid as timer scatters food inside of the square.

Each day:

- At the timer's signal, each forager begins to find food. Be careful not to use any strategy!
- Each day will be 60 seconds long.
- Each forager must get at least five pieces of macaroni to their next to survive to the next day or else they die

At the end of each day:

- Timer records how long it takes each forager to gather their five pieces
- Continue until both foragers have died

At the instructor's signal, the situation will change.

- Foragers face away from grid as timer re-scatters food inside of the square.
- Continue the experiment as before. This time, *one of the foragers will begin to use the best foraging strategy they can come up with*. The timer will continue to record each forager's time.

SITUATION #3

- Groups of three: timer, counter, forager
- Each group needs a set of tri-colored macaroni
- Use the same grid from Situation #2
- Foragers face away from grid as timer scatters food inside of the square.

Each day:

- Foragers must bring five pieces to the nest by the end of the day as usual.

At the end of each day:

- Timer records foraging time
- Counter keeps track of the number of each color gathered each day
- Continue until forager has died

RESULTS:

Create tables to contain information for each experiment. Be sure to record all times, numbers of macaroni, and general observations. Also, record any mistakes or problems noticed with the procedure or trial. Be sure that all group members get all information needed to answer questions. Hand data in with the Discussion section.

NATURAL SELECTION

"The sculptor of life"

DISCUSSION:

BACKGROUND:

1. What is natural selection? What are its three tenets?
2. What are some environmental factors which a population would need to adapt to?

SITUATION #1:

1. What happened in this experiment over time?
2. What is a population? How is a population modeled in this experiment?
3. How did the foragers evolve in this experiment? What did they evolve in response to?
4. How are the three tenets of natural selection modeled?
5. What is fitness? In general, which foragers where the most fit in this experiment? Why?

SITUATION #2

1. What happened in this experiment?
2. How did the strategizing forager differ from the other forager?
3. What was the control in this experiment?
4. How did the foragers evolve in this experiment? What did they evolve in response to?
5. Describe a situation in which a population of skilled foragers would go extinct. Describe one in which the prey would go extinct. Explain your reasoning behind each.

SITUATION #3

1. What happened in this experiment? What trend did you notice?
2. What advantage does an organism have with camouflage?
3. Was the effect of the cryptic coloration as significant in the second half of the experiment as it was in the first half?
4. How could this experiment be changed to model evolution of the predator? How could it be altered to model evolution of the prey?
5. Describe a situation in which *contrasting* coloration (so that the organism sticks out instead of blending in) would be beneficial.

NATURAL SELECTION

Lab Report Rubric

Overall:

	Pts possible	**Pts earned**
Throroughness, neatness, no grammatical errors, all in paragraph form. etc	**4**	
Error/improvements?	**2**	

Background

1. What is natural selection? What are its three tenets?	2	
2. What are some environmental factors which a population would need to adapt to?	2	

Situation #1 (15)

	Pts possible	Pts earned
Results:	(4)	
Overview of experiment in regards to data collection	1	
Statement of results	3	
Discussion:	(11)	
1. What happened in this experiment over time?	3	
2. What is a population? How is a population modeled in this experiment?	2	
3. How did the foragers evolve in this experiment? What did they evolve in response to?	2	

4. How are the three tenets of natural selection modeled?	2	
5. What is fitness? In general, which foragers where the most fit in this experiment? Why?	2	

Situation #3 (19)

	Pts possible	Pts earned
Results:	(9)	
Overview of experiment in regards to data collection	1	
Statement of results	3	
Data tables	(5)	
Colors	2	
Times	2	
Labeled	1	
Graphs?		
Discussion:	(11)	
1. What happened in this experiment over time? What trend did you notice?	3	
2. What advantage does an organism have with camouflage?	2	
3. Was the effect of the cryptic coloration as significant in the second half of the experiment as it was in the first half?	2	

4. How could this experiment be changed to model evolution of the predator? How could it be altered to model evolution of the prey?	2	
5. Describe a situation in which *contrasting* coloration (so that the organism sticks out instead of blending in) would be beneficial.	2	

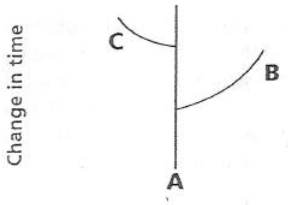
Group _____ Name _____

Fossil Study

In this lab, you will categorize fossils by similarities in morphology and age. You will then draw an evolutionary tree that depicts the relationship of these fossils.

Fossils are traces of organisms that lived in the past. When fossils are found, they are carefully excavated and then analyzed. One part of this analysis is to determine the age of the fossil. The absolute age of a fossil can be determined through radiometric dating. In **radiometric dating**, the amount of a certain radioactive element is compared to the amount of its decay element. Because the decay rate of the radioactive element (its half-life) is constant, the ratio of the two elements tells scientists the age of a fossil. Analysis also includes a study of the **morphology**, or physical characteristics, of the fossil so that the genus and species can be determined.

The age and morphologies of fossils enable scientists to place the fossils in sequences that often show a pattern of changes that have occurred over time. This relationship is frequently depicted in a diagram called an evolutionary tree. An **evolutionary tree** is a diagram that shows the evolutionary relationships among a group of organisms. The diagram below is an example of an evolutionary tree. Line A represents the original lineage, and the two branches, B and C, represent two new lineages that evolved from A.

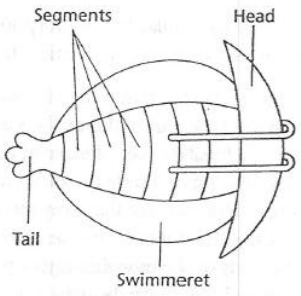


There are two major theories on how evolution takes place. Many scientists believe that organisms evolve through a process of slow and constant change called **gradualism**. Another theory states that some species evolve through the process of **punctuated equilibrium**. In punctuated equilibrium, species evolve very rapidly over a short time and then remain the same for very long periods.

1. The group of "fossils" you will work with are of fictional animals from the fictional genus *Crustaceus*. Each fossil on your fossil sample sheet (page 33 of this activity) is marked with the time period to which the fossil has been dated. Cut out each fossil, making sure to include the time period marked below it. You will need this information later.

2. Arrange the fossils by age. On your data chart, place each fossil next to the period identified with that fossil. The term *upper* means a more recent part of a period. The term *lower* means an earlier part of a period. Thus, fossils from an upper period should be placed near the top of the space allotted for that period, and those from a lower period should be placed near the bottom. If the period identified for a fossil is neither upper nor lower, place the fossil in the middle of the space. Place fossils from the same time period side by side. Do not tape or glue them in place yet.

3. While keeping the fossils in proper age order, arrange them by morphology. To give you an idea of what body parts to look for, examine the example of *Crustaceus*, with its labeled body parts, in the diagram at right. Then, carefully examine the morphology of each fossil. Begin by examining the oldest fossils, and work in sequence to the most recent. Note any changes from one time period to the next. Arrange the fossils using the following steps:



   a. Center the oldest fossil at the bottom of the "Fossil" column.

   b. Throughout the chart, those fossils that appear to be exactly the same as the fossils preceding them chronologically should be placed directly in a vertical line with each other.

   c. The first fossil that appears different from the one before should be placed 1/2 in. to the left of the fossil before it.

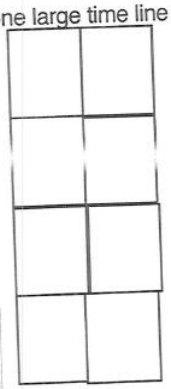
   d. During a certain period, the fossils will be split into two branches. In other words, one fossil from that period will show one type of change, and another fossil from the same period will show a different type of change. When this occurs, place one of these fossils 1/2 in. to the left of the fossil from the preceding time period. Place the other fossil 1/2 in. to the right of the fossil from the preceding time period.

   e. After the point of branching, place each fossil in the left-hand branch that exhibits a change 1/2 in. to the left of the fossil preceding it. In the right-hand branch, place each fossil exhibiting a change 1/2 in. to the right of the fossil preceding it.

4. Once all fossils have been placed correctly according to time and morphology, tape or glue the fossils in place.

Procedure for constructing the fossil time line:

Tape together eight sheets of plain white paper so that you have one large time line that is 17" across and 44" long:



You should generate a time table that looks like the one below.

The "fossils" column should be the entire right side of the time table (8.5" wide) and all of the time periods will all be 5" high, with the exception of the Idahoan which will be 1" high. The top row (containing the headings) will be 3" high. The time period column should be 6.5" wide; the "Began" and "Duration" column should be 2.5" wide each.

The time periods listed in the chart are fictional.

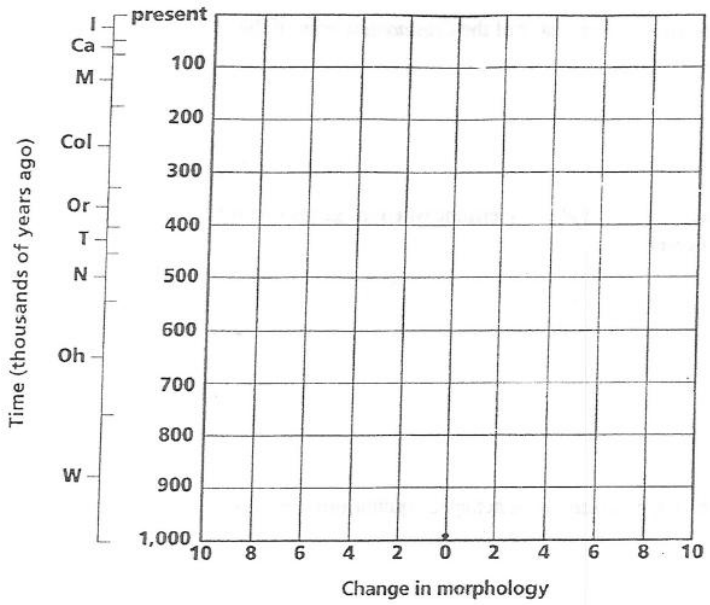
Be careful to copy the time periods in the correct order.

Fictional Time Periods

Time Period	Began (years ago)	Duration (in years)	Fossils
Idohoan (the present)	30000	30000	
Californian	80000	50000	
Montanian	170000	90000	
Colorodan	320000	150000	
Oregonian	395000	75000	
Texian	445000	50000	
Nevadian	545000	100000	
Ohioan	745000	200000	
Wyomingan	995,000	250000	

Analysis

Draw an evolutionary tree on the following graph for the fictional genus *Crustaceus*. The number 0 on the *Change in Morphology* axis denotes the physical appearance of the original (oldest) fossil. Each tick mark to either side denotes a change in morphology from one fossil to the next-youngest fossil.



Give a brief description of the evolutionary changes that occurred in *Crustaceus*. Refer back to the labeled diagram of *Crustaceus* above to review the terms used to describe the various body parts of the organism.

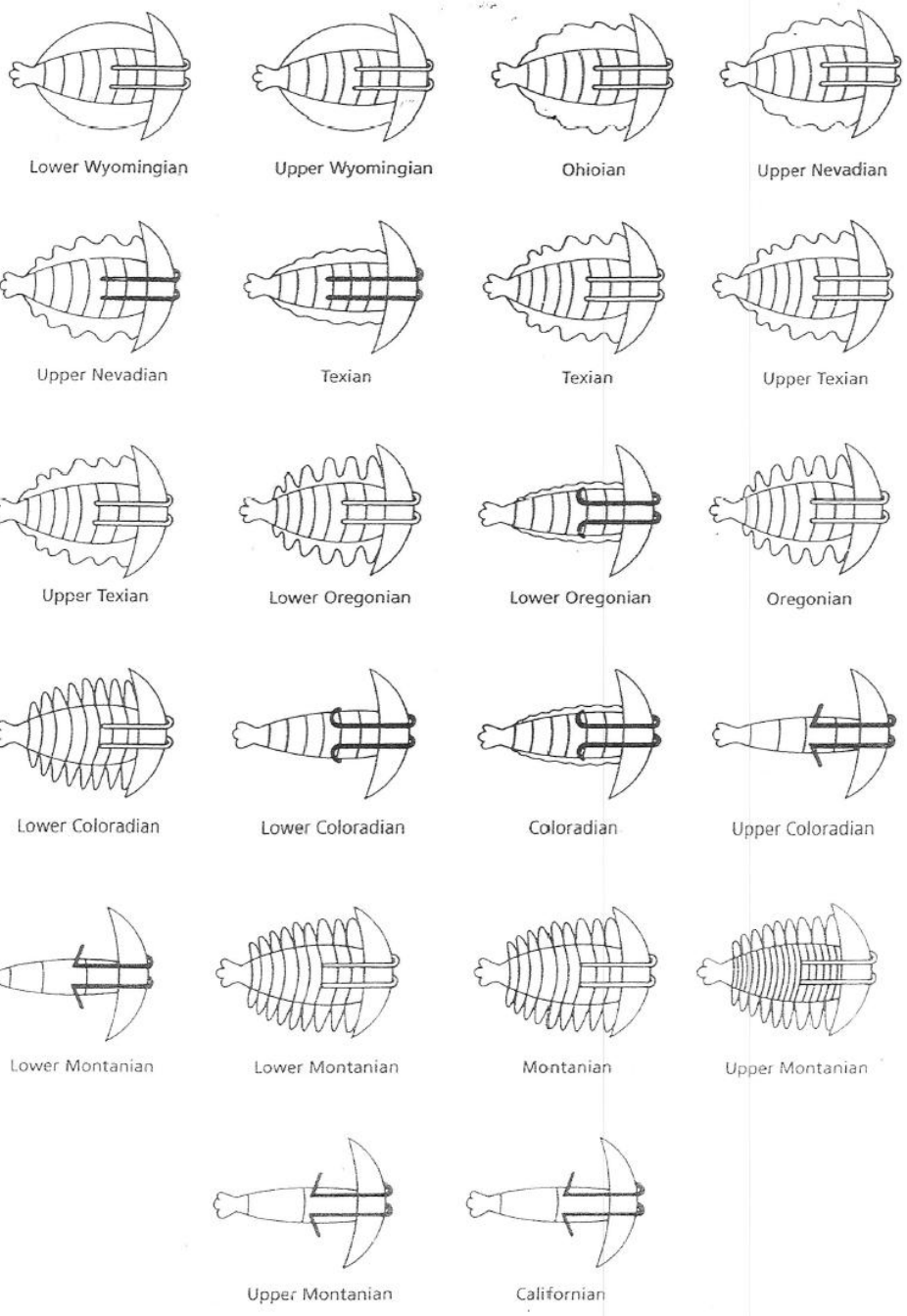
Conclusions

During which period did the fossils start to differentiate into two branches?

In what period does the common ancestor of the *Crustaceus* species of the Montanian period appear?

No examples of *Crustaceus* survive today. Determine when the genus became extinct. Support your answer.

Did the set of fossils show gradualism or punctuated equilibrium? Explain.


Lower Wyomingian
Upper Wyomingian
Ohioian
Upper Nevadian
Upper Nevadian
Texian
Texian
Upper Texian
Upper Texian
Lower Oregonian
Lower Oregonian
Oregonian
Lower Coloradian
Lower Coloradian
Coloradian
Upper Coloradian
Lower Montanian
Lower Montanian
Montanian
Upper Montanian
Upper Montanian
Californian

Name _____ Class _____ Date _____

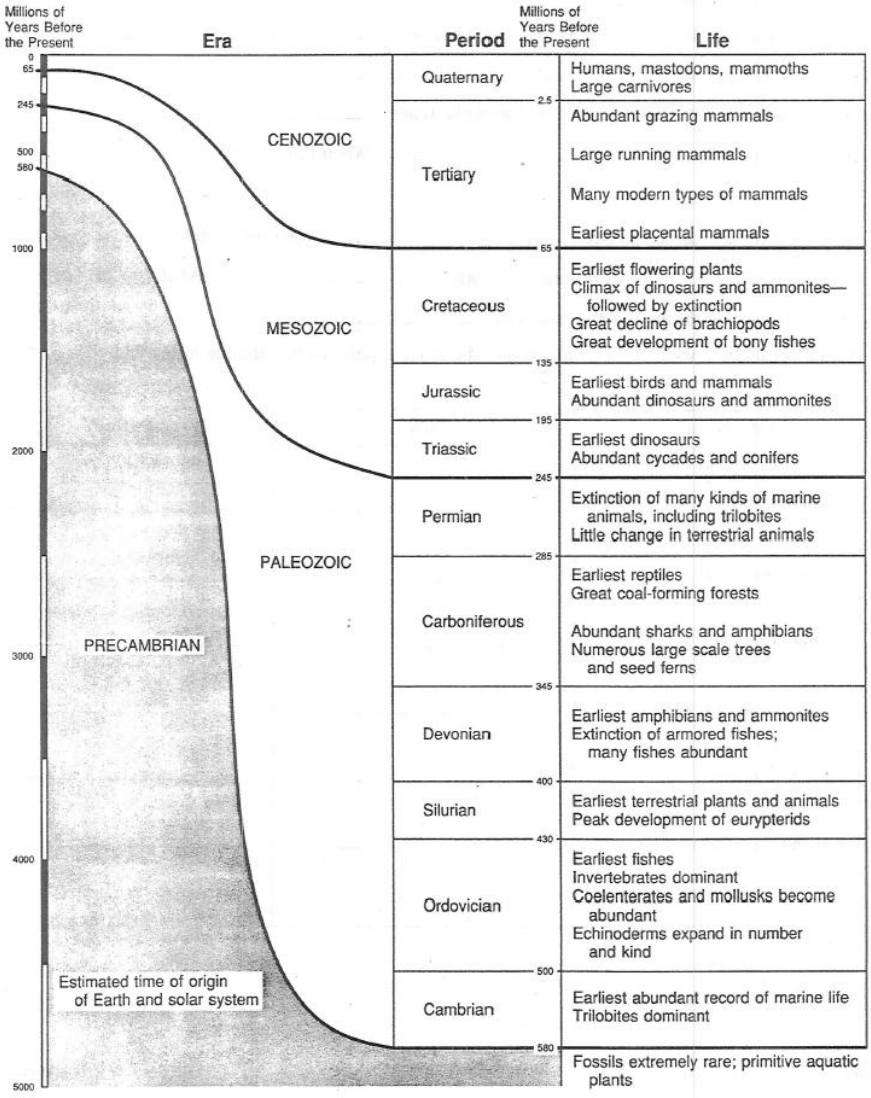
CHAPTER 13

Evolution: Evidence of Change
Section 13–2

SKILL ACTIVITY
Analyzing data

The Geologic Time Scale

Use the information from the diagram below to answer the accompanying questions.



1. According to the diagram, all of geologic time is divided into four large units called eras. List the four eras in order from the one that is most recent to the one that occurred farthest back in time.

_____ (most recent)

_____

_____

_____ (farthest back in time)

2. Which of the eras lasted for the longest period of time? _____

How long did it last? _____

3. Which era covers the shortest length of geologic time? _____

4. What time era do we live in? _____ When did it start?

_____

5. When did the Mesozoic Era begin? _____ When did it end?

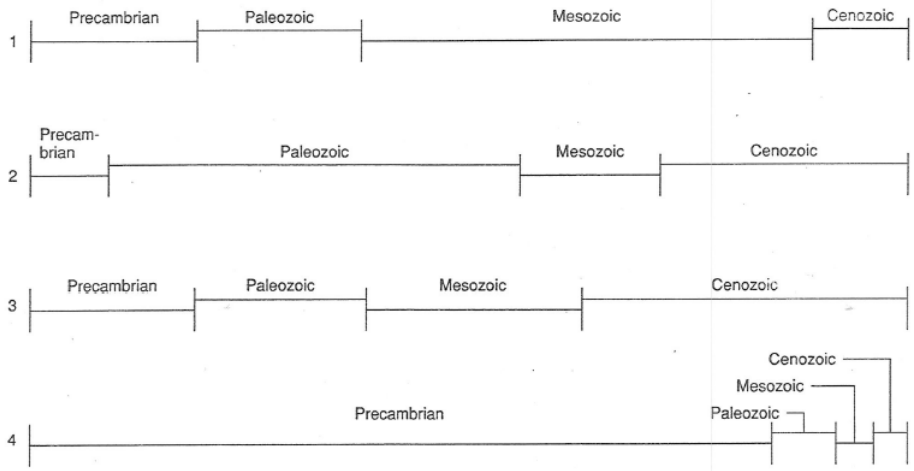
_____ How long did it last? _____ What type of animal lived only during the Mesozoic Era? _____

6. Complete the following chart by identifying the era and period when the life forms first appeared.

Life Forms	Era	Period
Earliest fishes	_____	_____
Earliest mammals	_____	_____
Earliest reptiles	_____	_____
Earliest flowering plants ...	_____	_____
Earliest humans	_____	_____
Earliest dinosaurs	_____	_____

Name _____ Class _____ Date _____

7. Which line is the best representation of the relative length of each of the geologic time intervals? _____



8. Which sequence of geologic time in the following list represents increasing lengths of time? _____

a. Ordovician, Triassic, Tertiary
b. Jurassic, Cretaceous, Tertiary
c. Triassic, Devonian, Cambrian
d. Carboniferous, Devonian, Cretaceous

GEOLOGIC TIME

Compared to the span of the earth's history, a human lifetime is very short. This makes it very difficult for any person to get a clear picture of the vast periods of time involved in geologic history. However, some idea of these time spans is necessary to understand the slowness of the processes that change the earth and the life on it. The procedures you will follow in this investigation will help you to make your discovery of the real meaning of geologic time.

Materials
meter stick
paper tape, 5 meters long
pencil

A. By converting geologic time into distances it will be possible for you to make a correctly scaled model of the earth's history. The first step is to convert periods of time into equivalent units of length. These lengths will then be marked on a long piece of paper tape.

In order to translate time into equivalent distances, you must first work out a scale. To do this, let 1 meter equal 1 billion (1,000,000,000) years.

1. Now complete the missing parts of the following scale. (Remember, 1 meter = 100 centimeters; 1 centimeter = 10 millimeters.)

   1 meter = _____ years

   1 centimeter = _____ years

   1 millimeter = _____ years

2. Using the scale you have developed, translate each of the ages given below into its equivalent distance in meters. For example, an age of 9 million years becomes 9 mm = 9/1,000 = 0.009 m.

Age	Time	Length in Meters
Maximum age of the earth	4.5 billion years	_____
Oldest known plants	2 billion years	_____
Oldest known animals (jellyfish)	1.2 billion years	_____
Paleozoic era begins (Cambrian period)	600 million years	_____
Ordovician period begins (first vertebrates)	500 million years	_____
Silurian period begins	440 million years	_____
Devonian period begins	400 million years	_____
Mississippian period begins	350 million years	_____
Pennsylvanian period begins	305 million years	_____
First reptiles	290 million years	_____
Permian period begins	270 million years	_____
Mesozoic era begins (Triassic period)	225 million years	_____
First mammals	200 million years	_____

Table 1a. Student Worksheet.

Geologic Time Scale

ERA	PERIOD	EPOCH	BEGINNING (Millions of years ago)	DURATION (Millions of years ago)	NUMBER OF METERS	MAJOR EVENTS
Cenozoic Era	Quaternary	Recent	Began 10,000 years ago			Civilization spreads. Human beings are the major form of life.
		Pleistocene	2.5	2.5		"The Ice Age." Modern human beings present. Mammoths and other animals become extinct.
	Tertiary	Piliocene	14	11.5		Fossil evidence of ancient human beings near the end of the epoch. Many birds, mammals, and sea life similar to modern types. Climate cools.
		Miocene	25	11		Many grazing animals. Flowering plants and trees similar to modern types.
		Oligocene	35	10		Fossil evidence of primitive apes. Elephants, camels, and horses develop. Climate generally mild.
		Eocene	55	20		Fossil evidence of a small horse. Grasslands and forests present. Many small mammals and larger mammals; such as primitive whales, rhinoceroses, and monkeys.
		Paleocene	70	15		Flowering plants and small mammals abundant. Many different climates exist.
Mesozoic Era	Cretaceous		135	65		First fossil evidence of flowering plants and trees. Many small mammals. Dinosaurs are extinct by the end of the period. Coal swamps develop.
	Jurassic		180	45		First fossil evidence of feathered birds and mammals. Many dinosaurs roam the earth.
	Triassic		230	50		Beginning of the "Age of Dinosaurs." Insects plentiful. Cone-bearing plants present.
Paleozoic Era	Permian		285	55		First evidence of seed plants. Fish, amphibians, and reptiles present.
	Carboniferous	Pennsylvanian Period	325	40		First evidence of reptiles. Many amphibians and giant insects present. Many large fern trees. Swamps cover many lowland areas.
		Mississippian Period	350	25		
	Devonian		410	60		"Age of Fish." First fossil evidence of amphibians and insects. Many different kinds of fish in the earth's waters. The first forests grow in swamps.
	Silurian		430	20		First evidence of land plants. Algae, trilobites, and armored fish plentiful. Coral reefs form.
	Ordovician		500	70		Fossil evidence of jawless fish. Algae and trilobites plentiful. Great floods cover most of North America.
	Cambrian		600	100		"Age of Invertebrates." Fossil evidence of trilobites, clams, snails, and seaweed. Seas spread across North America.
Precambrian		Proterozoic Era	4.6 billion	Almost 4 billion		Fossil evidence of bacteria and algae. Earth forms.
		Archeozoic Era				

EVIDENCE OF EVOLUTION

Information

Homologous structures are either identical or very similar in form. They provide evidence that organisms might have evolved from a common ancestor. Structures must be studied in great detail to make sure that they are homologous. For example, the front limbs of bats, whales, seals, birds, and frogs look very different. The front limbs of both birds and bats are used for flying, but the limbs of birds have feathers and the limbs of bats do not. The front limbs of both the whale and the seal are flippers, but the seal uses its flippers to support its body on land and the whale does not. The flippers on both the whale and seal might appear to have little in common with the front limbs of birds and bats. The front legs of a frog also appear to have little in common with the front limbs of other animals. These structures are not similar in function. However, an examination of the bones in each of these front limbs shows that the bones are very much alike. In fact, scientists say that the bones in these limbs are *homologous*.

Carefully examine the drawings of the bones shown in Figure 1. Note the similar positions of like bones.

Color each bone of the human arm a different color. (All bones of the wrist should be a single color, the bone groups of the hand should be a different single color.) Then color the similar bone in each of the other animals the same color as the human bone.

1. Describe the function of each set of bones below:

ANIMAL	FUNCTION
human	
whale	
cat	
bat	
bird	
alligator	

2. Are the bones arranged in a similar way in each animal ? Explain.

The bones in the front limbs of a bird, a bat, a whale, a seal, and a frog are shown in Figure 2. Use Figure 2 to answer the following.

3. Compare the names of the bones in each limb.

4. Compare the positions of the bones in each limb.

5. Explain the differences between the bird wing and the bat wing.

265

6. Which limb looks more flexible, the whale flipper or the seal flipper? Explain your answer.

7. Suggest a reason for the flippers of a whale being less flexible than the flippers of a seal.

8. Study the bones of the human arm that are shown in Figure 1.
Are these bones homologous to the bones that are shown in Figure 2? Explain your answer.

Examine the butterfly wing and the bird wing that are shown in Figure 3. Some apparently unrelated animals have organs with similar functions, yet are very different in structure and form. These structures are called *analogous* structures

9. What function do these structures share?

10. How do the structures differ?

11. Do birds and insects share any structural similarities that would suggest they are closely related?

12. List at least two ways in which the wing of the bird and the wing of the butterfly are different.

Gradual changes have occured through time that have in some cases changed the function of some body structures and organs. The penguin's wing and leg bones of snakes are examples of this phenomenon. Organs or structures that have changed their function in the organism and become reduced in size (because of efficiency) are *vestigial* structures.

The cave fish and minnow (Figure 4) are related, but the cave fish is blind.

13. Explain why eyesight is not an important adaptation to life in a cave.

14. Does the appearance of the cave fish and the minnow suggest common ancestry? Why?

15. Explain why the homologous structures in Figure 1 are evidence of evolutionary relationships

16. Explain the evolutionary relationship between the fin of a fish and the flipper of a whale.

600

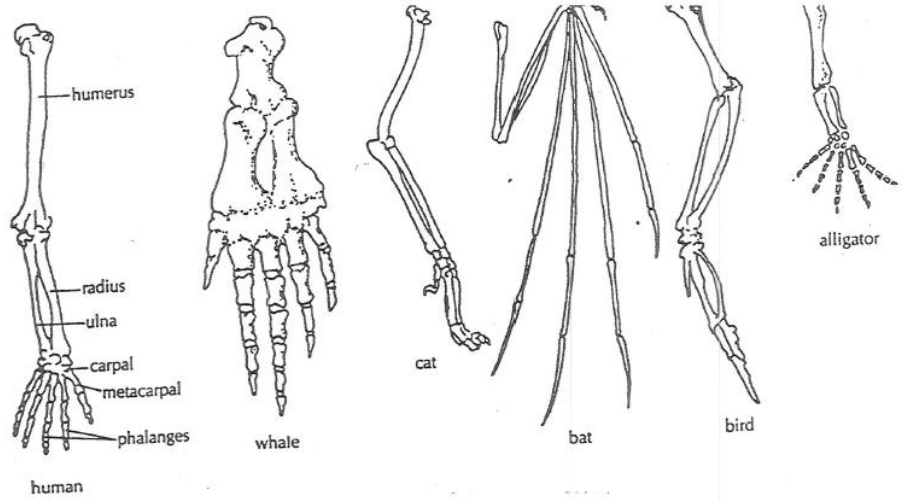


Figure 2

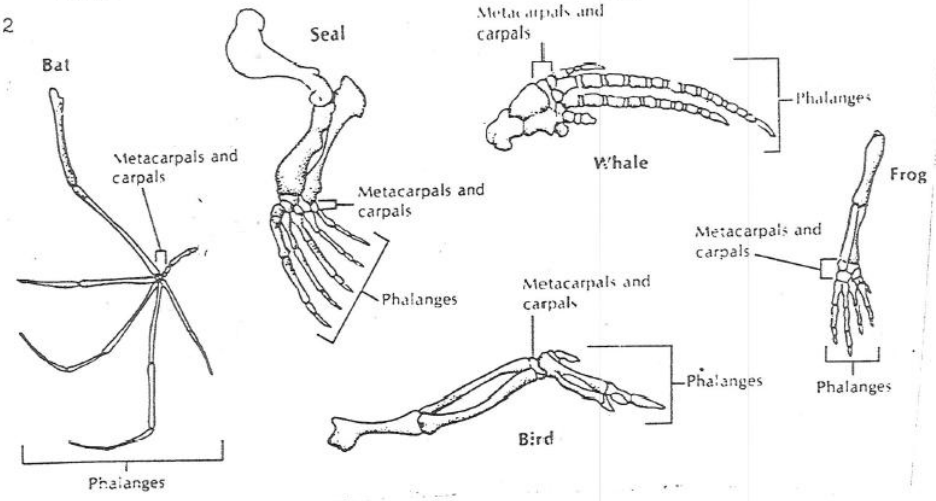


Figure 3

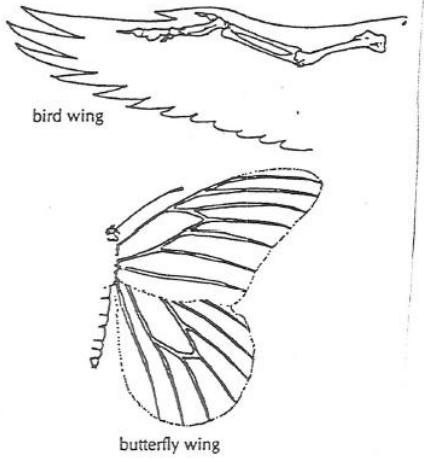
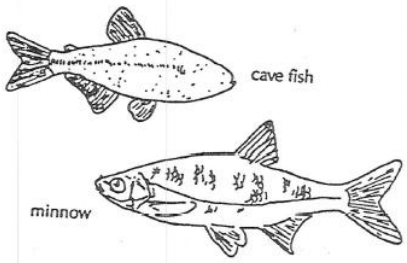


Figure 4



AMINO ACID SEQUENCES AS EVIDENCE OF EVOLUTION

Information

Homologous structures - those structures believed to have common origin but not necessarily a common function - provide some of the most significant evidence supporting the theory of evolution. While homologous structures can be used to demonstrate relationships between similar organisms, they are of little value for determining evolutionary relationships among those structures that are dissimilar.

Another technique used to determine evolutionary relationships is to study the biochemical similarity of organisms. Though molds, aardvarks and humans appear to have little in common physically, a study of their proteins reveals certain similarities. Biologists have perfected techniques for determining the sequence of amino acids in proteins. By comparing the amino acid sequences in homologous proteins of similar organisms and of diverse organisms, evolutionary relationships that might otherwise go undetected can be determined. Biologists believe that the greater the similarity between amino acid sequences of two organisms, the closer their relationship. Conversely, the greater the differences, the more distant the relationship. Further, biologists have found that such biochemical evidence compares favorably with other lines of evidence of evolutionary relationships.

In this investigation you will:

A. Compare amino acid sequences in proteins of several vertebrates.

B. Compare amino acid differences and infer evolutionary relationships among some diverse organisms.

Examine Figure 19-1, which compares corresponding portions of hemoglobin molecules in humans and five other vertebrate animals. Hemoglobin, a protein composed of several long chains of amino acids, is the oxygen-carrying molecule in red blood cellls. The sequence shown is only a portion of a chain made up of 146 amino acids.

1. Using Figure 19-1, determine the amino acid that is DIFFERENT from that in human hemoglobin. In the appropriate spaces in number 1, write the abbreviated name of each differing amino acid.

2. Complete Table 2 to show the number of amino acid differences and the positions in which they vary.

3. In how many positions are the amino acids the same in each organism?

4. On the basis of their hemoglobin similarity, what organisms appear to be most closely related to humans?
   Explain your answer.

5. Among the organisms that you compared, which one appears to be least closely related to humans?
   Explain your answer.

6.7

Another commonly studied protein is cytochrome c. This protein, consisting of 104 amino acids, is located in the miotochondria of cells. There it functions as a respiratory enzyme.

1. Examine Figure 19-2. Using human cytochrome c as a standard, construct a bar graph to show the amino acid differences between humans and other organisms.

2. Examine Figure 19-3. In this figure cytochrome c of a fruit fly is used as a standard in comparing amino acid differences among several organisms. Construct a bar graph of these differences.

3. On the basis of differences in their cytochrome c, what organisms appear to be most closely related to humans?

4. What organisms appear to be least closely related to humans?

5. Check the pair of organisms that appears to be most closely related to each other:

   _____ snapping turtle - tuna fish

   _____ snapping turtle - rattlesnake

   _____ snapping turtle - pigeon

   Explain your answer

6. Agree or disagree with the following statement, and give reasons to support your answer. "fruit flies appear to be more closely related to silkworm moths than they are to screwworm flies."

7. Name the pair of organisms that appears to be equally related to humans on the basis of cytochrome c similarity.

8. Is it possible that organisms in question 7 could be equally related to humans but not equally related to each other?

   Explain your answer.

9. Agree or disagree with the following statement. "Fruit flies and humans have about the same evolutionary relationship to wheat."

10. There is a difference of only one amino acid in one chain of the hemoglobin of humans and gorillas. What might have caused this difference?

11. If the amino acid sequences in the proteins of two organisms are similar, why will their DNA also be similiar?

12. Many biologists believe that the number of differences between the proteins of different species indicate how long ago the species diverged from common ancestors. Why do these biologists believe that humans, chimpanzees, and gorillas diverged from a common ancestor only a few million years ago?

to 8

	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Chimpanzee	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Gorilla	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Rhesus monkey	GLN	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Horse	ALA	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Kangaroo	LYS	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU

	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Horse	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	ALA	LEU	VAL	VAL	ALA	ARG
Kangaroo	ASN	PHE	LYS	LEU	LEU	GLY	ASN	ILE	ILE	VAL	ILE	CYS	LEU	ALA	GLU

Fig. 19-1

1.

87 88 89 90 91 92 93 94 95 96

Human

THR LEU SER GLU LEU HIS CYS ASP LYS LEU

Chimpanzee

_____

Gorilla

_____

Rhesus monkey

_____

Horse

_____

Kangaroo

_____

97 98 99 100 101 102 103 104 105 106

Human

HIS VAL ASP PRO GLU ASN PHE ARG LEU LEU

Chimpanzee

_____

Gorilla

_____

Rhesus monkey

_____

Horse

_____

Kangaroo

_____

107 108 109 110 111 112 113 114 115 116

Human

GLY ASN VAL LEU VAL CYS VAL LEU ALA HIS

Chimpanzee

_____

Gorilla

_____

Rhesus monkey

_____

Horse

_____

Kangaroo

2. Complete the table to show the number of amino acid differences and the positions in which they vary.

Table 19–1

Organisms	Number of amino acid differences	Positions in in which they vary
human and chimpanzee		
human and gorilla		
human and Rhesus monkey		
human and horse		
human and		

Species Pairings	Number of Differences
Human - chimpanzee	0
Human - fruit fly	29
Human - horse	12
Human - pigeon	12
Human - rattlesnake	14
Human - red bread mold	48
Human - rhesus monkey	1
Human - screwworm fly	27
Human - snapping turtle	15
Human - tuna fish	21
Human - wheat	43

Fig. 19-2

Species Pairings	Number of Differences
Fruit fly - dogfish shark	26
Fruit fly - pigeon	25
Fruit fly - screwworm fly	2
Fruit fly - silkworm moth	15
Fruit fly - tabacco hornworm moth	14
Fruit fly - wheat	47

Fig. 19-3

Name:_____ Date:_____

Honors Biology Evidence of Evolution Test (100 pts)

Matching: *Match the correct statement/discoveries/developments with the scientist(s) responsible for them. Some letters may not be used, and some scientists may have multiple letters matched to them.*

1. _____ Buffon & Lamarck

2. _____ Darwin & Wallace

3. _____ Haldane & Oparin

4. _____ Kettlewell

5. _____ Lamarck

6. _____ Lyell, Smith & Sutton

7. _____ Malthus

8. _____ Stanley Miller

a. Chromosome Theory
b. Created amino acids from non-organic molecules
c. Endosymbiont Hypothesis
d. "Food supplies grow arithmetically"
e. Found evidence of biological evolution
f. Found evidence of chemical evolution
g. Geologists
h. Heterotroph Hypothesis
i. Law of Superposition
j. "Life adapts to a constantly changing environment"
k. "Life changes all the time"
l. "Life is a struggle to survive"
m. "Natural factors select better-adapted individuals to survive"
n. "Populations grow exponentially"
o. "RNA World" Hypothesis
p. "Survival of the fittest"
q. "The first life-forms fed on the organic soup."
r. "Use it or lose it"

Multiple Choice: *Select the* best *possible answer for each question.*

9. Which of the following is not true of the Theory of Evolution?
   a. It has been proven true
   b. It has been revised as new facts were found
   c. It has provided a basis for experimentation
   d. It has stood the test of time

10. The human embryo and embryos of all other animals with backbones have gill slits. This best supports the idea that
   a. all animals with backbones are related.
   b. fish are in the same species as humans.
   c. fish are our closest relatives.
   d. the embryo breathes under water.

11. Which of the following gases was *not* used in Miller's apparatus?
   a. CH_4 b. H_2O c. NH_3 d. O_2

12. The bee's wing and the bat's wing could be called
   a. analogous structures.
   b. comparative anatomy.
   c. homologous structures.
   d. vestigial organs.

13. The characteristics of a species are determined by
   a. differential expression of a common genetic makeup.
   b. divergent or convergent evolution of the species.
   c. the amount of food and territory available to each member.
   d. the characteristics of the individual members of the species that survive and reproduce.

14. Assume that a species lives in an area where there are many predators. Also assume that this species has no means of defense besides climbing trees. You would expect that
   a. fewer short-armed individuals would survive than long-armed individuals.
   b. mutations would cause other methods of defense to develop.
   c. the species would become extinct.
   d. the species would develop long arms because of much use.

15. In general, the lower the rock layer,
   a. the fewer the differences
   b. the less preserved the organisms
   c. the more complex the organisms were
   d. the younger the fossils

16. Darwin based much of his theory of evolution on
   a. environmentally acquired characteristics.
   b. mistakes in DNA replication.
   c. the struggle for existence.
   d. the use and disuse of organs.

17. Sexual reproduction is a significant factor in evolution. This is true because it provides for
    a. changes in how DNA duplicates itself.
    b. production of genes.
    c. the only means for continuing any species.
    d. variation in offspring.

18. Which structure in humans might be considered a vestigial organ?
    a. Poorer sense of smell compared to other primates
    b. Smaller canine teeth than any other primate
    c. Thick hair growth on the top of the head
    d. Thin body hair compared to other primates

19. Cheetahs and leopards are closely related. If cheetahs developed opposable thumbs, while leopards developed more hoof-like feet, it would be an example of
    a. convergence
    b. divergence
    c. homology
    d. natural selection

20. What is the strongest evidence for the Theory of Evolution?
    a. Family trees
    b. Fossil records
    c. Published works of authorities
    d. Studies of modern organisms

21. The Law of Superposition relates most to which of the following items?
    a. Absolute dating
    b. Fossils
    c. Relative Dating
    d. Theory of Evolution

22. Radiometric dating relates most to which of the following items?
    a. Absolute dating
    b. Fossils
    c. Relative Dating
    d. Theory of Evolution

23. The endosymbiont hypothesis says that
    a. All organisms evolve through symbiosis with some other type of organism
    b. An organisms can only get along with other animals in its own population
    c. Large organisms (ex. humans) may have other organisms (ex. bacteria) inside of them
    d. Mitochondria and plastids originated from free-living prokaryotes

24. Which of the following is evidence for the theory of an expanding (post-Big Bang) universe?
    a. Blue shift of the planets
    b. Fossils of explosive material on meteorites
    c. Planets on the outskirts of the universe are moving slower
    d. Red shift of the planets

25. Chemical evolution is
    a. difficult to test in the lab.
    b. disproved by the Heterotroph Hypothesis.
    c. the idea that life evolved from chemicals.
    d. the idea that all evolution happens through changes in molecules like DNA.

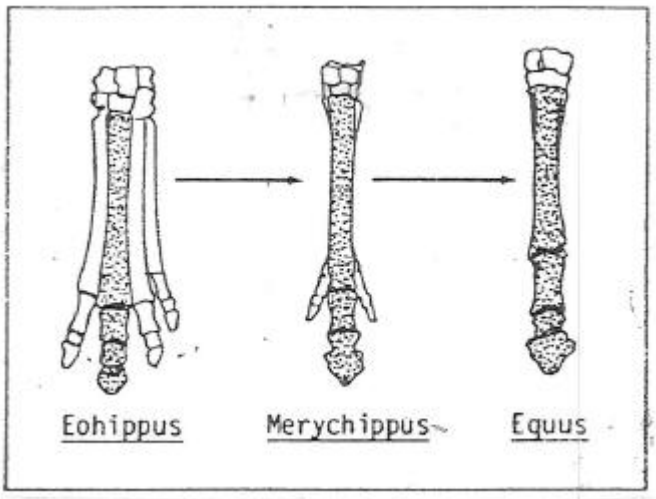
26. The "RNA World" Hypothesis suggests that
    a. Molecules didn't need clay anymore since RNA can catalyze.
    b. RNA came before protein since it can catalyze and can code for proteins.
    c. RNA was the first organic molecule on Earth.
    d. RNA was the first nucleotide to give chemical systems continuity.

27. Which of the following is *not* necessary for biological evolution?
    a. Development of a new species
    b. Inheritable mutations
    c. Natural selection
    d. Self-reproduction

28. When did biological evolution on Earth begin?
    a. As soon as there was DNA to mutate.
    b. At the origin of life.
    c. When the Earth was formed.
    d. When the first organic molecules formed.

29. Which of the following is not true of Carbon dating?
    a. $C^{14} \rightarrow N^{14}$
    b. Half-life of 25,000 years
    c. Up to 50,000 years
    d. Uses a radioactive isotope

*The following five questions are "True or False" questions based on the diagram below. The diagram shows the structure of the limbs of two extince horses (*Eoippus *and* Merychippus*) and the limb of a modern horse,* Equus.



30._____ The three limbs are similar in function and origin.
31._____ If Lamarck were examining these limbs, he would probably say that toes were lost through disuse.
32._____ If Darwin were examining these limbs, he would probably say that *Equus* and *Merychippus* lived at the same time.
33._____ The three types of horses probably passed on acquired characteristics.

34. Which of the following represents these relative lengths of these time units?

a. epoch < era < period
b. era < epoch < period
c. epoch < period < era
d. period < era < epoch

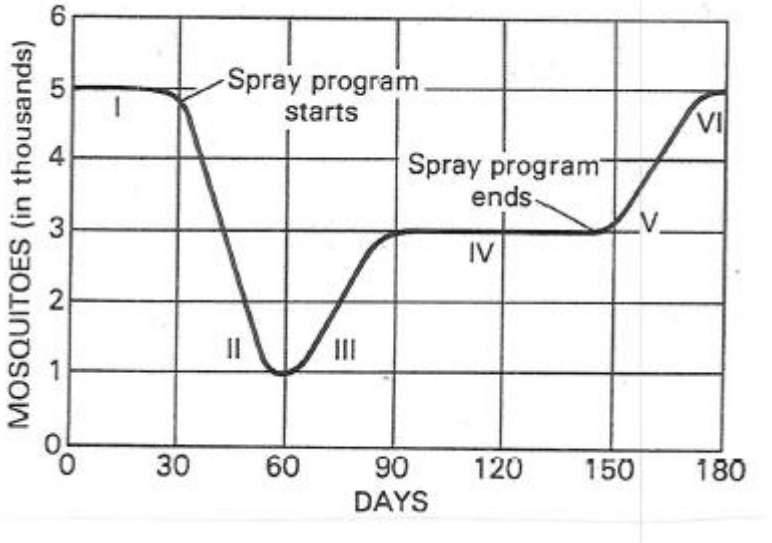
35. An organism could be defined as
a. a biochemical system that can evolve
b. a chemical system that can reproduce with another chemical system
c. a chemical system that maintains homeostasis and has continuity
d. a specific member of a species

36. Which would *not* be a step in the Oparin-Haldane hypothesis for the origin of life?
a. A supply of organic molecules were produced by nonbiological processes.
b. Some processes had to assemble those small molecules into polymers.
c. A molecule for heredity formed.
d. Polymers organized into a replicating unit.

37. New species are formed when two populations
a. are separated by a geographic barrier
b. can no longer interbreed
c. differ phenotypically
d. live under different climatic conditions

The next four items are based on the following information and graph.

A tropical island was heavily infested with mosquitoes. It was sprayed with DDT over a period of several months. Daily counts of population size yielded the following data.



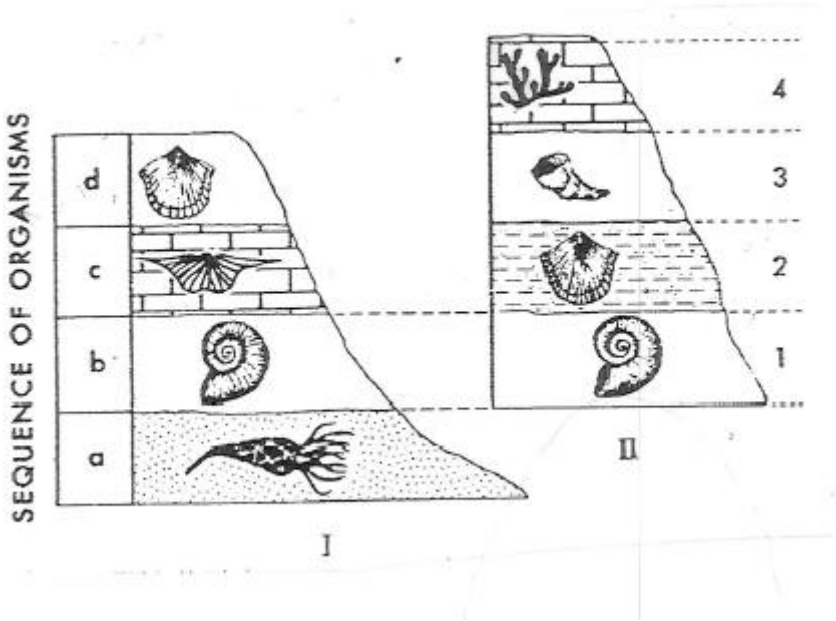
38. A change in the genetic makeup of a population as a result of natural selection is illustrated best by the section of the graph labeled
a. I
b. II
c. III
d. IV

39. The number of mosquitoes being born and the number dying are balanced in the section of the graph labeled
    a. I c. III
    b. II d. IV

40. The difference in the genetic makeup of the mosquitoes is the greatest between Points
    a. I and IV. c. I and VI.
    b. III and IV. d. IV and VI

41. On the basis of this graph, which of the following statements can be made?
    a. All of the original mosquitoes were killed by the end of the 30 days.
    b. Mosquitoes are not sensitive to DDT.
    c. The population decreases after spraying.
    d. The population is permanently reduced in 120 days after spraying.

The following four questions are based on the following diagram. The diagram shows sedimentary rock layers and various organisms found in them. The layers in Locality I were found several kilometers away from those in Locality II. The labels a-d and 1-4 refer to the different strata.



42. What is the evidence that these are sedimentary rocks?
    a. the fossils b. the layers c. both a & c d. none of the above

43. The increase in complexity in organisms through time
    a. cannot be inferred from this diagram
    b. is clearly shown here
    c. is indicated by their positions in the rock strata
    d. is not possible

44. Assume that no geological shifts have taken place. If this is the case, the organisms in
    a. stratum a are the oldest
    b. stratum a are the simplest
    c. stratum d are the oldest
    d. stratum d are the simplest

45. Which stratum in Locality II might be continuous with stratum d in Locality I?
    a. stratum 2 b. stratum 3 c. stratum 4 d. none of the strata

Name:_____ Date:_____

Honors Biology Evidence of Evolution Test (100 pts)

Practical Exam

46. Cats and humans are both mammals (meaning they are more closely related to each other than to the frog). Theorists believe that mammals evolved after amphibians like the frog. What structure on the mammal skeletons illustrates divergence of a structure on the amphibian skeleton? Explain you answer.

47. Use two specimens in the selection which are analogous structures, and explain why you chose them.

48. Use two specimens in the selection which demonstrate convergence, and explain why you chose them.

Name:_____ Date:_____

Honors Biology Evidence of Evolution Test (100 pts)

ANSWER SHEET

1. _____
2. _____
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42. _____
43. _____
44. _____
45. _____

Appendix F – Ecology Review

This appendix contains notes from a review of ecology presented to the honors students. The frameworks served as an outline. All key points in ecological studies were included. Some of the topics were a review, others were knew information. Students took notes, but no assessments were done. The lecture was done in one period. This was a very informal lecture which was meant solely to fulfill frameworks requirements and prepare students for the Biology MCAS.

ECOLOGY

interaction between living organisms & their envipo.

ENVIRONMENT

anything around org.

- ABIOTIC FACTORS
  - nonliving
  - water, energy, climate, etc.
- BIOTIC FACTORS
  - living/organic

ECOSYSTEM

biological community & its abiotic environment

- ecosystem is like a huge organism
  - homeostasis
  - adaptation
  - they can die or be born

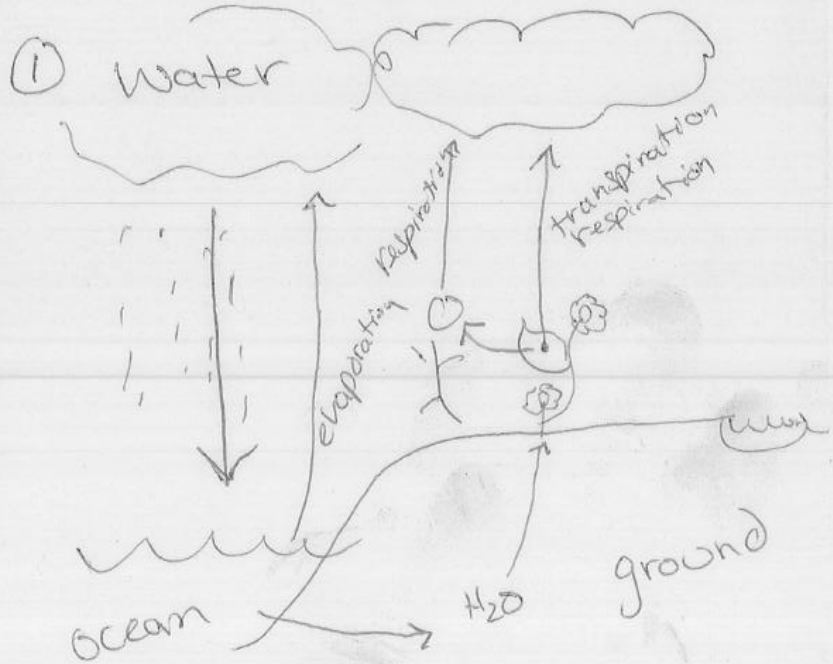
dead zone — heterotroph hyp.

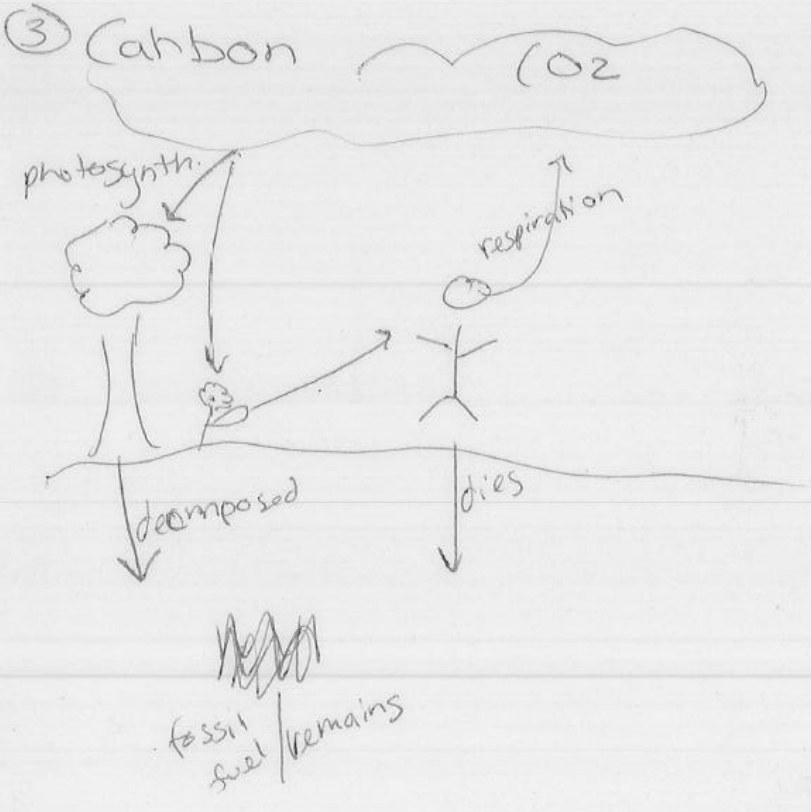
I CYCLES

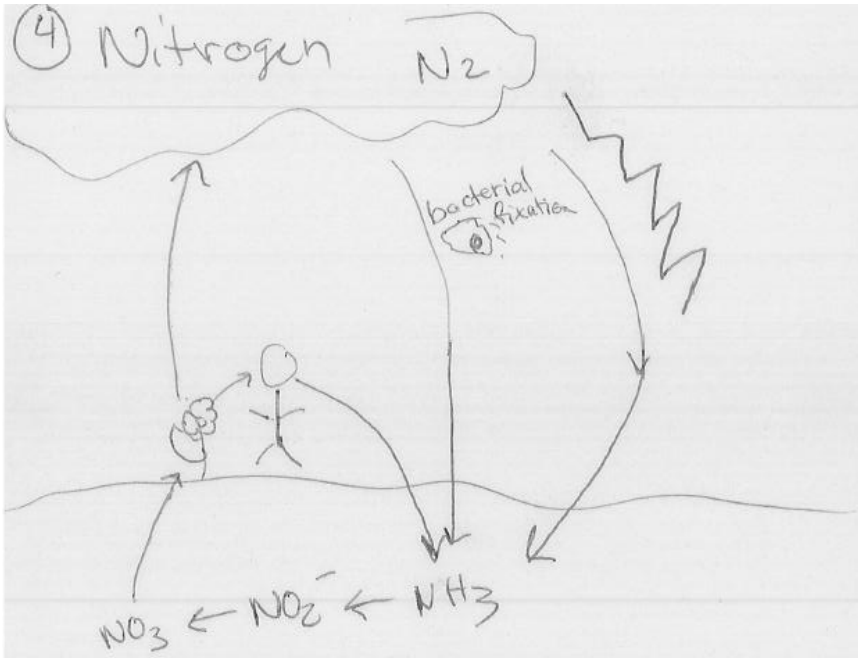
- Law of Conservation:
  "matter neither created /destroyed"

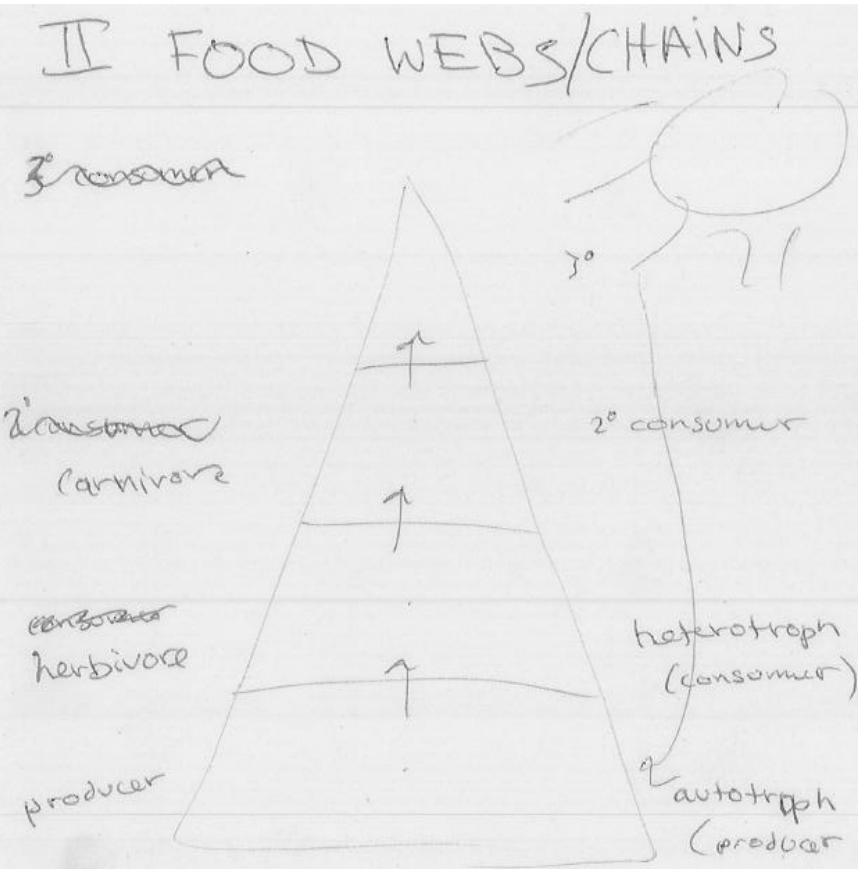
- matter is recycled

1. Water
2. Nitrogen
3. Oxygen
4. carbon









2° carnivore
↑
carnivor
↑
herbivore
↑
plant

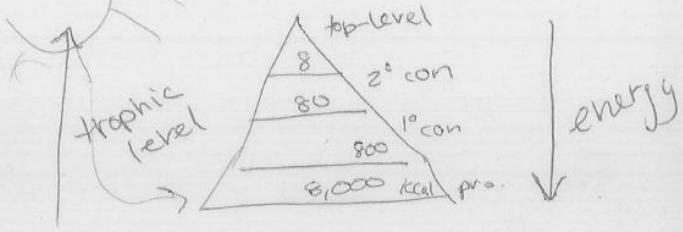
Autotroph -
producer

Heterotroph -
consumer
- HERBIVORE
- CARNIVORE

③

TROPHIC LEVEL

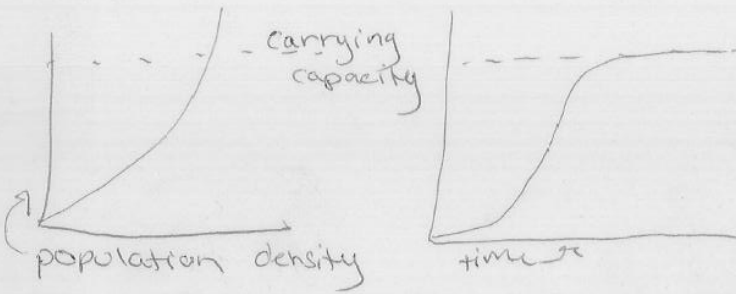
- describes nutritional roles



Food Chain = linear

a Web = all relationships - network

III Population Size



exponential = possible, potential

logistic = actual

~~carry~~

CARRYING CAPACITY

largest population of a species the environment can support

Limiting FACTORS

resources which limit carrying capacity/pop size

(4)

Limiting factors

1, abiotic
2. Competition
3. Predators
4. parasites

} not all

① resources!

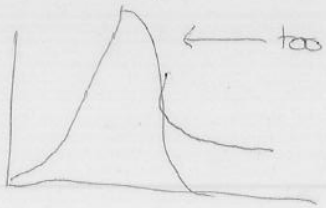
· this is why the cycles are essential

② Competion

· niche = where you fit

③ Predators/prey

④ Parasites



← too dense, spread of disease

IV Changes

- Ecosystems are like huge organisms- they need to adapt or they die

BIOMES

regions w/ different physical environments/ vegetation
- "planet earth show"

Deserts

- hot, dry, little precipitation, or cool
- few perennials (<1 most)
- few trophic levels

Rain forest

- wet, hot, near equator (lots of sun)
- lots of vegetation, diversity & trophic levels
- layers

Savanna

- grasslands
- rich soil
- world's largest herbivores
- 3 seasons (cool/dry, hot/drag, warm(wet)

Deciduous Forest

- 4 seasons
- humid, lots of precipitation
- trees (several layers of plants)
- diverse animals

Taiga

"northern coniferous forest"
- high elevations
- cold!
- little growth under thick trees

Tundra

- high alt.
- cold
- small plants, shallow roots

Aquatic Systems

Changes

① Population dispersal - emmigrant

② new species

③ ~~abiomans~~
- evolved
- immigrant

③ climate
- ice age / global warming

④ resources change
- ice → water
- new species → more N?

⑤ HUMANS
• affect all of those changes
• conquered the world, maybe space someday

- urban sprawl
- aggriculture
- pollution
- create islands
- use up resources

(1)

V Symbiosis

SYMBIOSIS

relationships between species

- Mutualism

  both benefit

- Parisitism

  one benefits, one suffers

- Commensalism

  one benefits, other unaffected

	S1	S2
M	+	+
P	+	−
C	+	NA

COMPETATIVE EXCLUSION PRINCIPLE:

"Two species can't occupy same niche in same ecosystem for long"

(8)