Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2008 Volume VI: Depicting and Analyzing Data: Enriching Science and Math Curricula through Graphical Displays and Mapping

Monitoring an Epidemic: Analyzing Through Graphical Displays Factors Relating to the Spread of HIV/AIDS

Curriculum Unit 08.06.04
by Heidi A. Everett-Cacopardo

Student Population and Rationale

The tenth grade students I interact with provide an engaging audience at a New Haven magnet school for health sciences, business, and technology. They are an inquisitive group that enjoys enhancing their understanding of the world in which they live. Most of the students I teach have not traveled outside their communities and are curious about what the world beyond the streets of their communities. The advances in technology have provided a wealth of resources on the Internet giving the students access to quantitative information about various factors affecting human populations around the world. Spreadsheet software programs enable me to take a topic like human population growth, and develop activities that allow the students to manipulate data sets and create graphical displays. This unit is intended to expand upon what the students have learned from analyzing population pyramids of developed and developing countries. Large amounts of data have been collected on the HIV/AIDS cases around the world and are accessible on the Internet. The students will access data on HIV/AIDS using the wealth of databases that has been collected on this epidemic to compare and contrast developed and underdeveloped countries. The portion of the unit devoted to HIV/AIDS will have an epidemiological component.

I have designed this unit to align with the district standards for content covered in a biology course regarding scientific literacy, numeracy, and science, technology and society. Although this unit is designed for a high school biology course, graphing is an interdisciplinary skill used at all grade levels and parts of this unit could easily be used for middle school and used in a math or civics class. This unit is broken into two parts that may either be taught consecutively or at different times in the school year. The first section on graphing skills I intend to teach at the beginning of the school year due to the importance of this skill in science. Part two of my unit will be an extension of an established unit on population pyramids of developed and underdeveloped countries. Students will use their graphing skills to generate their own graphs using data on HIV/AIDS cases in developed and underdeveloped countries. The students will be introduced to epidemiology, and then will learn to use HIV/AIDS databases to develop an appropriate graph. The students will use the graphs they have generated on the HIV/AIDS and then evaluate the relationship between their graph and the population pyramid of the country they have analyzed HIV data on.

My district curriculum places this unit on population pyramids around the third marking period and this is why I will not teach the two sections of my unit consecutively. The unit on population pyramids is a required science, technology, and society (STS) task. The state of Connecticut tests all biology students during our state standardized assessment on population dynamics using population pyramids. I have found this unit on population pyramids unproductive in providing the students with the opportunity to interact with the factors that are behind the shape of a population pyramid. I am hoping to enhance the students' understanding of analyzing population pyramids by creating a strong connection with the factors molding the demographics of various countries through student generated graphics completed by hand and through the use of spreadsheet software programs. The culminating assessment for the unit will be students generating appropriate graphical displays on HIV/AIDS cases from a developed and underdeveloped country and determining how the data on HIV can be linked to the population pyramids of each country.

Teaching Strategy

Science is a subject that easily provides many avenues to engage the curiosity of students. There are typically a variety of means to make a "real world" connection during a biology lesson. In my opinion, the easiest aspect of teaching science is bringing relevance to a lesson. However, in order to teach a subject dealing with a population numbering in the billions the students must think "outside the box" and call upon their creative talents. Tactile activities can reinforce concepts in a unit and activate creative thinking. Hands on activities help those students who learn by doing and provide a better foundation for the students who need more then recording notes in class. I try to implement various activities that call upon Howard Gardner's Multiple Intelligences Theory (Campbell, 2004) when planning a unit. Generating data through a fictional school wide outbreak of an infectious disease created by the students is one example of how I will try to connect the statistics of HIV/AIDS to an actual event-taking place in the classroom.

The topic of human population growth can be considerably difficult for students to grasp. Students view the world through only the lens of their experiences. The idea of a population being decimated by an infectious disease is a foreign concept since my students live in a developed nation like the United States. The citizen of a developed country typically does not encounter an epidemic because public health agencies and healthcare services usually prevent the spread of an infectious disease. In addition, the standard of living in a developed country is often taken from granted. My students have access to clean, running water, toilets, medicine, electricity, and food. This access may not be available to the average citizen of an underdeveloped country.

Currently, AIDS is ravaging African countries and this disease does not receive as much media attention as it should in the United States. Africa is not alone in its plight with HIV/AIDS. The World Health Organization estimates that the number of people infected and living with HIV/AIDS is "between 35 to 42 million" (4% of the world's population) (WHO, 2004). Throughout the world, certain regions have large populations infected with HIV. Unfortunately, many students do not pay attention to the media, as most of them do not read periodicals or watch the news. In order to focus their attention on the global AIDS epidemic, I will open the second part of the unit with an introduction to epidemiology and use an activity that involves paper dolls representing a number of HIV/AIDS infected individuals. Students will be given paper dolls with sets of numbers and the names of countries around the world. These paper dolls represent "people" in populations of countries where HIV/AIDS is present. Throughout the lesson, I will announce the number and country of the paper dolls held by the students, and have the students place their dolls on the map of the world. My intent is to provide a visual

of the countries that have populations infected with HIV. I hope this activity will emphasize that HIV infection is taking place all around the world right at the same moment that we are learning about statistics of disease. Each time a student's paper doll number is called, we will add the doll to a world map created by the students. The students will then take the numbers on each paper doll and then make a choropleth map with data on the paper dolls. This choropleth map or map chart will serve as an example for the students to reference throughout the portion of unit on graphing HIV/AIDS.

The communities that my students live in appear to be healthy and unscathed by infectious diseases like AIDS. However, an individual infected by AIDS will not be easy to distinguish from an uninfected individual. My students seem to be completely unaware that they most likely have encountered someone who is HIV positive in their life. Urban communities who are home to large minority groups are at greater risk for exposure to various infectious diseases. African American populations are at a greater risk for HIV than other minority groups; however, the Hispanic population is predicted to see an increase in number of infections (CDC, 2006).

In many sub-Saharan African countries, the number of people dying due to HIV is difficult to comprehend for those who have never been exposed to an epidemic. I hope to provide the students with a sense of the number of people dying from AIDS more realistic through a fictitious infectious disease outbreak that they will monitor and collect data on as it "spreads" throughout the building and classrooms. A map of the building will depict where the outbreaks are taking place and be used as an example of a choropleth map or map chart depicting populations.

Science, Technology, and Society

The science, technology, and society component of the curriculum is a focal point around which this unit revolves. The unit is based on human population growth and the factors that shape the population pyramids of developed and underdeveloped nations. I choose AIDS as the infectious disease to investigate throughout the unit due to its prevalence in both developed and underdeveloped countries and the horrific role it is playing in reshaping the demographics of many countries.

It is my opinion that the generation that I currently teach does not have an appropriate fear of HIV. I believe that there is a false sense of security due to the increased life span of people infected with HIV because of advancements in treatments. I have witnessed first hand student discussions that indicate that many of my students are ignorant of the risks associated with their sexual activities, some do not believe that HIV is in their communities, and many believe that they have never met anyone with HIV. I hope that that the second part of my unit will serve to awaken my students to the realities of HIV/AIDS cases in their own communities, nation, and the world at large. I hope to instill an appropriate awareness of the damaging effect of HIV/AIDS on the health of human populations around the world.

Unfortunately, some countries who have large numbers of people infected with HIV are not recognizing HIV, as a deadly infectious disease slowly wiping out large portions of their populations. Certain countries in sub-Saharan Africa face the loss of the important generational knowledge concerning sustainable farming practices with the death of the family member who is unable to pass on their knowledge to their young children. In addition, a portion of the populations that is highly educated government officials, teachers, military leaders, and bankers are dying from HIV/AIDS (Garrett, 2005). These educated individuals are

important contributors to the stability of a country and with their loss comes the erosion of the progress that certain developing countries have made toward better quality of life through economic growth.

The slow demise of the immune system caused by HIV allows opportunistic infections like TB to be listed as the cause of death. This ambiguity allows some countries to remain in a state of denial that large segments of their populations are dying from HIV/AIDS (Garrett, 2005). The stigma associated with the disease has lead to some countries to shroud the numbers of their population infected with HIV and dying from AIDS. China for example chooses not to disclose the actual incidence and prevalence of the disease in their population. HIV infected individuals do not die quickly and the antiretroviral drugs available to those with the financial resources are prolonging the life of many HIV positive individuals making it appear that HIV is not present in the population. It is easy to overlook the damage that HIV infections are taking on populations around the world. I intend to highlight the differences in resources regarding healthcare and biotechnology for developed versus underdeveloped countries and how these resources could be testament of the advancements of science and technology working together for the common goal of public health, if they were made available worldwide.

The students I teach are a mix of health science and business majors. I always try to incorporate the business aspect of science because business and science go hand in hand in providing funding for research and the development of new biotechnologies. Analyzing data and depicting data appropriately are skills used by both scientists and businesspersons. Many students believe science is devoid of "business practices." I want to make the students aware that science and business are involved together in major way, as in the biotech/pharmaceutical industry and its role in the battle against AIDS. The students should also understand that these companies require an educated work force and an economy that can provide monies.

Unit Objectives

The students will:

1. review strategies for effectively organizing data in a table.
2. develop data tables that effectively organize data.
3. review the steps involved in creating a graph (title, labeling x and y axis, independent and dependent variables, and scale).
4. compare and contrast a line graph, bar graph, histogram, pie chart, and map chart.
5. distinguish between a developed and underdeveloped country.
6. compare and contrast the shapes of population pyramids of a developed and underdeveloped country.
7. analyze the factors that shape the pyramids of different countries.
8. define and distinguish between an epidemic and pandemic.
9. define the terms prevalence and incidence.
10. apply the terms prevalence and incidence in analyzing statistics regarding HIV/AIDS cases throughout the world.
11. research factors that contribute to the differences in HIV/AIDS cases in a developed and underdeveloped country.

12. choose three factors from their research related to HIV/AIDS cases and summarize how they have affected the shape of developed and underdeveloped country's population pyramid.

13. decide what type of graph is appropriate for displaying the factors they have researched data on dealing with HIV/AIDS in a developing and developed country.

14. evaluate how the data they have graphed on HIV/AIDS is related to the population pyramid of the countries they have investigated.

15. evaluate how science and technology benefit the health of human populations.

Unit Background

Constructing Data Tables and Graphs

In order to be able to generate an appropriate graph it is imperative that the students understand the difference between the independent and dependent variables. Not all graphs follow the rule of the independent variable on the x-axis and the dependent variable on the y-axis, however this is an important piece of information that students need to master in order meet the state standards for scientific literacy and numeracy. I teach my students about the differences between the dependent and independent variables by first discussing everything that could possibly change in an experiment. The class generates a list of all of the possible variables or things that could change throughout the experiment and then I have them choose one variable that they would like to have direct control over to change between their different experimental groups. The variable they choose to change purposely becomes their independent variable. The students are then asked to decide what variable they would like to measure that would be affected by the independent variable they have chosen. The variable they have decided to measure either qualitatively or quantitatively due to their independent variable will be their dependent variable (Cothron, 2000). I inform the students that the "i" in independent can help them remember "I" have control over changing the independent variable but the "d" in dependent variable produces "data" that they measure at a result of the changes they make with

the independent variable.

The students will be given the opportunity to evaluate summaries of different experiments to determine which variables described are the independent and dependent variables. This exercise will help them apply their knowledge of the independent and dependent variables. I have included a few examples of summaries under the appendix called "Examples of Independent and Dependent Variables Identification Scenarios."

Students work hard at designing a controlled experiment but often are deficient in their ability to generate their own table to organize the data. Some labs provide a data tables already organized for the students. I believe this practice is contributing to students failing to understand the importance of the data table. A data table that effectively depicts the relationship of the dependent and independent variable is critical for a student to depict the data in the appropriate graph. Data tables provide the first step to inferring the relationship between the independent and dependent variable. I often find that students will graph a label or identifying number from a prepared data table, thinking it is the independent variable. I hope that by having them construct their own effective data tables will be better equip them to distinguish the real independent and dependent variables on their charts. The independent and dependent variables should be placed in vertical columns with additional vertical columns provided for additional calculations for the data and or labels of experimental groups. It is important for them to understand that by staying organized in constructing their data table the easier it will be to record their data and then analyze the data they have collected.

Constructing a Graph

Once the students have practiced creating an effective data table to organize the collection of their data, they will then be reintroduced to the steps of constructing a graph. It is important to ask students what graphs are and why they are used. I will have the students brainstorm in groups what they think the purpose of graphing is for and then have each groups share their ideas to the class. I hope this will create a dialogue about what purpose a graph holds for scientists and society. I want the students to understand that graphs visually represent data sets that allow quick conclusions to be made about the overall trends found within the data sets.

The first step in constructing a graph is determining what columns in the data table provide the data for the independent and dependent variables. After the independent and dependent variables have been identified, then draw and label the axes by placing the names of the independent variable on the x-axis and the dependent variable on the y-axis along with the unit of measurement that was used for each variable. I will explain to the students that they will find graphs that do not follow this rule but should understand that this will be the method that graphs are constructed in their science classes throughout high school. The next step is determining the intervals that make up the scales for the x-axis and y-axis. This is a very difficult step for the students in the process of constructing graphs. It is the most common error that I find in the graphs my students construct. I try to reinforce this difficult concept by showing them a meter stick and having them tell me about what they observe about the tick marks and the numbers represented on the meter stick. Typically, the students recognize that there is a standard distance between the tick marks and the numbers are in chronological order.

In order to provide a more tangible visual of the concept of scale, I have created a jumbo interactive graph is displayed on the wall in my classroom. I took butcher paper and made the x-axis and the y-axis using a permanent marker and placed tick marks on each axis. I then took index cards and wrote the following generic names of key parts of the graph on each index card (title, x-axis, y-axis, independent variable, dependent variable, scale, units, labels, and the numbers 1-15). I placed tape on the back of the labeled index cards and

then placed them in the correct region of the graph. I go through the parts of the graph by showing the students the correct placement of the cards on the parts of the graph to provide them with a visual of all of the parts of a good graph. I make sure to focus on the scales of each axis to show them that if I make each tick mark worth 1 then the scale should read 1-15. However, if I make each tick mark worth 2 then the tick marks or intervals that divide my axis should be labeled with 2, 4, 6, 8, 10, 12, and 14.

After I have shown them a few examples of various intervals, I then "make a mistake" in dividing my scale into equal intervals and have the students identify what is wrong with my scale and how it should be fixed. I do this a couple of times with different intervals for the students to grasp the concept of scale and then refer back to my meter stick and have them compare and contrast the meter stick to the scale of my jumbo graph. I have the students draw their own example of the jumbo graph on graph paper for their notes. The next class I have after introducing my jumbo graph, I place my labels incorrectly on the graph and I call upon individual students to tell me what is wrong with my labels and where I should place them to correct the mislabeled graph. This activity provides me with insight as to how much information was retained from last class and helps to reinforce the graphing rules introduced last class. I repeat this activity all throughout the year to keep reinforcing graphing as the students easily forget their knowledge.

Spreadsheet Programs and Graphs

The business department at our high school instructs the freshman class on how to use spreadsheet programs and how to create graphs with the data sets they have entered into the programs. Due to time constraints, I will do a quick refresher lesson on using spreadsheet programs with an emphasis on transforming data sets into graphical form. I hope this review on spreadsheet programs will refresh the minds of students who already have had training and help those students who have transferred and have not received any instruction on using spreadsheet programs. At the end of the unit, under the appendix section, I have provided a tutorial on how to create graphs using a spreadsheet program (see "Create Graphs Using Spreadsheets").

There are some important terms that I want the students to be familiar with when using spreadsheet programs. Some spreadsheet programs refer to graphs as "charts" and this could provide some confusion to students. Another source of confusion may be found with horizontal bar graphs labeled as bar charts and vertical bar graphs labeled as a column charts. The scatter plot can also be referred to as a XY chart.

Accessing International HIV Data Sets

The World Health Organization's Statistical Information System (WHOSIS) provides health statistics on 193 countries from around the world through a database that allows you to choose various indicators from various countries. You can produce a table using the selected indicators and the table can be transformed into a line, bar, or pie graph. The WHOSIS database also allows you to download the datasets from the various indicators you have chosen and then export the data into a .csv file. This type of file (.csv) can be used in any spreadsheet program. The database is very user friendly and the web address is #18 under "Websites on HIV/AIDS Statistics." Once you are on the web page, look under "QUICK SEARCH" and then click on "SHOW ALL COUNTRIES." You are then within the database and can click on the various countries you are interested in then click on the "INDICATORS" tab on the top of the countries table. Choose your indicators, then click on create a table at the top of the indicator selection box. A table should appear with the countries and indicators you have chosen. Next, you can create a chart by clicking on the tab on the "CHART" tab on top of the selection box. The system will create a line graph, but in the top left hand corner, you can choose column or a pie graph. When I have the students use this website, I plan on having them first create a chart or graph using the WHOSIS system and then download the data and also produce a graph using a spreadsheet program.

The following graph below (Fig.1) is an example of a graph I have made using the WHOSIS database using a spreadsheet program. One issue I have had with graphing the data is that the developed countries have such a small value compared to the developing countries concerning a certain indicator that the data points may not even be visible. One way to alleviate this problem is to have the students also graph the data by hand.

Figure 1
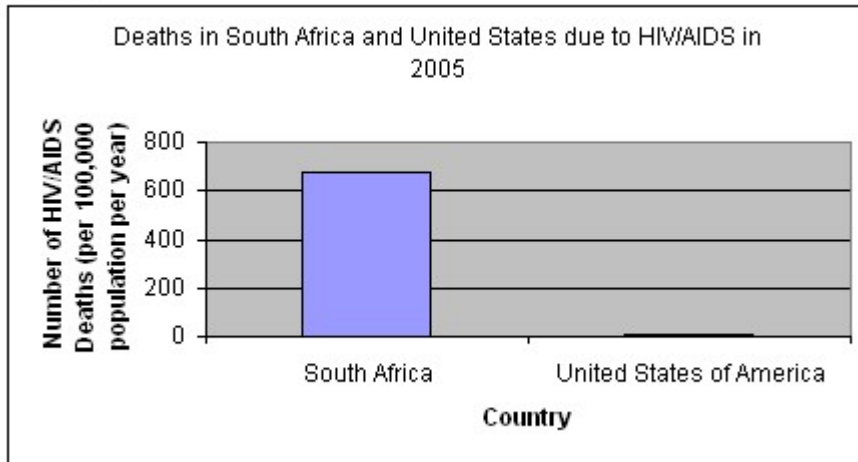
Types of Graphs and Charts

The next step in developing the student's graphing skills is determining what type of graph to use when analyzing a data set. I first provide the students with notes on the various types of graphs used in science and highlight that the data they have collected or are provided with determine what type of graph to use. The main graph and chart types we will employ in the unit are bar, line, pie, map charts, and population pyramids. I will introduce and briefly review box plots and histograms but I do not have the time to have students depict data using these two types of graphs. The students will first observe examples of each of the following graphs listed below and then take notes defining the various types of graphs.

Bar Graph

Bar graphs are one the most familiar types of graphs to the students and often their first choice in depicting data graphically. The bar graph is best used for comparing a small number of groups. For example comparing different types of brands of toothpaste, favorite types of foods, number of males and females in a class, different types of fertilizer. If each group being compared is "discrete" or categorical and is not related to each other numerically then a bar graph is the most appropriate graphical display to use (Cothron, 2004, p.53). Horizontal and vertical bar graphs are both used for comparing different groups and for time series data sets. I will emphasize that we use the vertical bar graph more then the horizontal. The vertical bar graph is referred to as the column chart on some spreadsheet software programs and I will make the students aware that the column chart is also known as a vertical bar graph. There can also be double bar graphs comparing two groups at the same time. For example, a double bar graph could be used to compare, by year, the number of boys and girls playing video games over the span of a decade. Students have difficulty in recognizing there should be a uniform width to each bar they construct and space or inter space between each bar on the vertical axis. An exception to this rule would be in using a multiple bar chart (Schmid, 1983). I will provide examples of each of these types of graphs by having a sample set of data already plugged into a spreadsheet software program projected onto a screen using a LCD projector.

The stacked bar graph is used when each component of the bar represents a percentage of the whole, like a pie chart (see below). This type of graph can be visually misleading because it is difficult to determine the amount each component contributes.

Line Graph and Scatter Plots

Line graphs are also very familiar types of graphs to the students, but students typically make many errors when constructing a line graph. The line graph is best used for when the independent and dependent variables are both continuous sets of data where the intervals between each data are related numerically. In line graphs, time is usually on the x-axis. Scatter plots are frequently used in science and follow the rules of the independent variable on the x-axis and the dependent variable on the y-axis. This type of graph is appropriate for determining relationships between two variables although more then two variables can be depicted. Different data sets may also be depicted on one line graph or scatter plot. Distinctive labeling should be used to distinguish the different datasets, for example different colors or patterns (Schmid, 1983).

Histogram

Histograms, also called frequency charts, are visually related to the vertical bar graph. Data sets that deal with frequency and distributions are best simplified by determining the number and size of the class intervals or bins. Once this has been determined, "count the number of data points in each interval, and plot the counts as bar lengths" (Chambers, 1983, p.24). Determining the class interval or bin size is critical in depicting the data appropriately. Data can be lost if too large of a bin size is chosen when constructing a histogram and choosing a bin size that is too small can produce a cluttered display with too many intervals that may not even contain any data points (Schmid, 1983). This type of graph is the basis for a population pyramid, which is one of the main graphical displays used to study population dynamics.

Population Pyramids

Population pyramids or age structure diagrams are the best graphical display for comparing the sex and age distribution of a population. This graphical display is constructed using a paired horizontal bar graph. Each age range is given a bar in chronological order starting with birth at the bottom. The length of the bar corresponds to the percentage of the population that makes up a certain range. These types of graphs are also helpful in predicting the type of growth a population can expect for a population's trends in age and sex distribution (PA Dept. of Health, 2001).

Pie chart

Pie charts are used for depicting discrete categories that are part of a whole. A data set looking at the percentage of the entire population of men, women, and children infected with HIV would be appropriately displayed with a pie chart. Pie charts can visually mislead the observer how to what percentage of the pie each category takes unless the percentage values are included in the graph. Pie charts are best used with data sets containing less then eight groups (Schmid, 1983).

Map chart Choropleth Map

Map charts or choropleth maps are used for depicting a data set that is spatially distributed over an area. A data set looking at the number of HIV cases found within each state is an example of data appropriately displayed using a choropleth map of all fifty states. The various shades used to color in each state could

indicate different ranges of values of HIV cases within each state. The darker shaded areas could indicate values. Start by determining the range your values cover and then divide the range into the number of categories you wish to depict. Usually on three, four, or five groups are best. A greater or lesser number of groups can obscure the data.

Misleading Graphs and Charts

There are many types of graphs and charts that when used correctly provide a visually engaging and appropriate summation of the relationships that certain data sets hold. Although graphs can communicate more effectively than a data table, they can also mislead and shroud the actual relationships or trends. Minute details like absent labels on the axes and the inappropriate scales are some common errors (Schmid, 1983). Choosing the wrong graph or chart type can easily destroy effective communication of the data. An example would be using a pie graph for a data set containing more then eight categories. Another example would be choosing bin sizes that are so large that certain data points end up being lost. Pie graphs are more decorative and should not be used to precise data due to the difficulty in assigning a precise percentage of the slice. These various points will be highlighted throughout the section on graphing and review of the various types of graphs and when to use them.

Introduction to Epidemiology & HIV/AIDS

Epidemiology is the study of the spread of diseases throughout a population. Epidemiologists focus on determining when a disease appears in a population, the mode of transmission, and where the disease spreads to in a population (Tortora, 2002). This field of biology focuses on many factors that are related not only to the origin and spread of disease but also the way in which people are affected by the disease. Some important pieces of information or data that an epidemiologist collects on a member of a population deal with the age, sex, occupation, personal habits, socioeconomic status, and history of immunizations. The following are key terms that students need to know the definitions of: etiology, prevalence, incidence, and mortality rates. Etiology is defined as all the variables that are considered as factors in causing disease in an individual (Philips, 2001). Incidence refers to the "number of new cases" of disease that take place over a certain amount of time, for example the number of HIV infections during the year 2001 (Phillips, 2001, p.10). Prevalence is similar but counts the number of cases already present in a certain population over a period of time. Mortality or morbidity rate is the number of deaths that take place during a year (Phillips, 2001). This vocabulary is important for the students to understand when analyzing the data sets provided on the World Health Organization statistics web page called WHOSIS.

Comparing and Contrasting Populations

My students will have already received instruction on the criteria used to determine whether a country is developed or underdeveloped based on the shape of a country's population pyramid. I will remind them that the shape of developing country has a very wide base. This wide base indicates a large portion of the population is composed of very young age groups and as the age increases, the trend is each age groups shrink in size. The developing country's population pyramid tends to narrow with increasing age. The narrow top of the pyramid indicates very few older people make up the population indicating a very low life expectancy for individuals in this population. Botswana is a country that has a population pyramid with a wide base and narrows toward the older age groups.

The shape of a population pyramid from a developed country will have either a narrow base due to fewer younger people in the population and or the overall shape ends up resembling an irregular block due to each

age groups being composed of roughly the same amount of people (PA Dept. of Health, 2001). United States is a country that has a population pyramid with a blockish shape due to the large middle age portion of the population. Developed countries have larger percentages of their population aging and this provides the more blockish shape in comparison to the pyramid shape of the developing country. Various examples of population pyramids I am describing can be found at website #10 listed under "Websites with Population Statistics."

I often find my students tend to overlook the units of a number as an unimportant detail. I tell the students to pay attention to the units (for example, thousand versus millions) that describe the population of a country by showing them a pyramid from a country with a small population (ex. Jamaica) with a country with a very large population (ex. China). I want to make sure the students understand that critical values are the percentages of a population that fall in various age groups rather than the absolute number.

Unit Outline

The first part of this unit is intended to reintroduce data tables and graphical displays in conjunction with the district standards that require the students to develop scientific numeracy skills. To be scientifically literate, a student must be able to generate data tables and analyze them appropriately through the construction of a graphical display.

The students have certainly received training in graphing before they enter my class as sophomores. However, accessing their prior knowledge and correcting misconceptions concerning analyzing data through graphical displays are important places to start at the beginning of the school year.

The second portion of the unit is devoted to using the students' graphing skills in analyzing the effect of HIV/AIDS on developed and underdeveloped countries. I will begin this section of the unit devoted to analyzing HIV/AIDS statistics with a review of the data analysis skills that are covered at the beginning of the year in science courses. The students will recall the portion of the unit devoted to the foundational principles of transforming quantitative information into appropriate graphical displays from the beginning of the year. The students will evaluate various data sets on HIV/AIDS and decide what type of graph they should be employed to appropriately display the data.

The students should be familiar with constructing the classic line and bar graphs, but often have difficulty in determining where they should place the variables on the graph and the importance of an equally divided scale. The other major goal for the unit devoted to graphing is developing the students' confidence in determining which type of graph is appropriate to use for a certain data set. I originally intended to do more an exploration of the various types of graphs and their appropriate application; however, the unit is built around the population pyramid STS task that takes place later in the school year. I have decided due to time constraints to focus on pie charts, map charts or choropleths, stacked bar graphs, bar graphs, and line graphs as the main graphical displays. These graphs will be used in the second part of the unit on HIV. I will briefly discuss scatter plots and how they are made but will not use them in the first section of the unit on graphing.

The first section of the unit dealing with graphing will also include a basic introduction on using a spreadsheet software program for analyzing data and creating graphs. The business department does cover the use of spreadsheet software programs in their computer courses from freshman. I will activate the students' prior

knowledge about manipulating data in a spreadsheet program using a systematic tutorial that I have included in my appendix under lesson plans.

Some of my students are health science majors others are business majors due to the schools' dual magnet themes. Analyzing data and depicting data appropriately is a skill used by both scientists and businesspersons. Graphical depictions can mislead the viewer. Whether the students have the goal of going into science or business each one should have, the ability to recognize when information is misleading and leads to drawing an invalid conclusion. An informed citizen should be able to analyze a graph and detect flaws with the way in which the information is being presented. The students will compare and contrast various types of graphs and determine what quantitative information is appropriately displayed in each type of graph. Special emphasis will be placed on building the students' skill to analyze poorly constructed graphical displays that may mislead visually.

The students will apply their knowledge of graphics by being provided with various graphical displays that include both "good" and "bad" graphs. The students will determine if the rules of using a certain graph have been followed and if the graphs are misleading. I have included links to bad graphs (see website #1) and good graphs (see website #1,2,3) in the appendix section of my unit under teacher resources. I recommend finding "bad" graphs online to reinforce the point that not everything on the web is "good." I have created poor graphs using spreadsheet software that can be accessed by going to the teacher resource section. The examples I have created are a pie graph (Fig. 2) using all fifty states and their percentage of the AIDS cases each state has out of the entire AIDS cases for the entire country. Pie graphs should only contain a maximum of eight groups in order to allow for appropriate visual distinction between the slices. I have also included a bar graph (Fig. 3) using the same data on cumulative number of HIV cases in all 50 states. The bar graph does not provide for easy distinction between the various states and the legend cannot fit on the page due to the number of states. The data used to make the bar graph below is from the CDC, HIV/AIDS Surveillance Report: Cases of HIV Infection and AIDS in the United States, 2006, National Center for HIV, STD, and TB Prevention, Centers for Disease Control and Prevention, Department of Health and Human Services, 2008. The Kaiser Family Foundation supports the web page www.statehealthfacts.org. This website provided the data below in downloadable spreadsheet format that allowed for my graphical display using a spreadsheet software program.
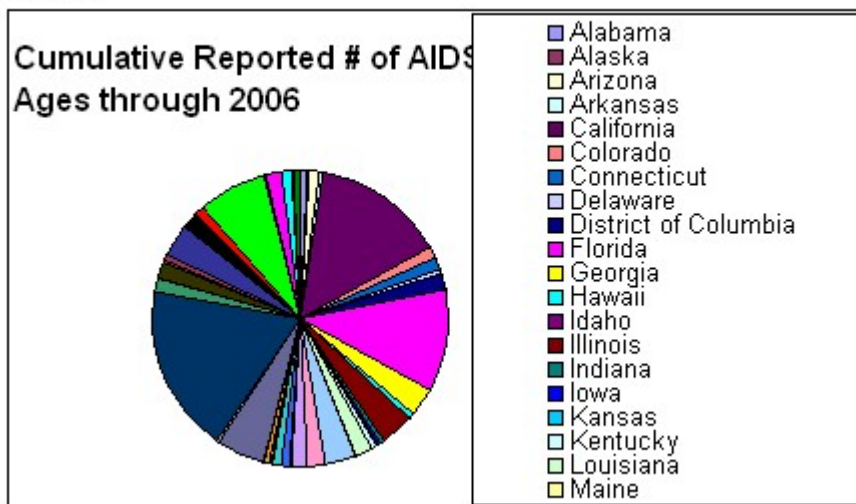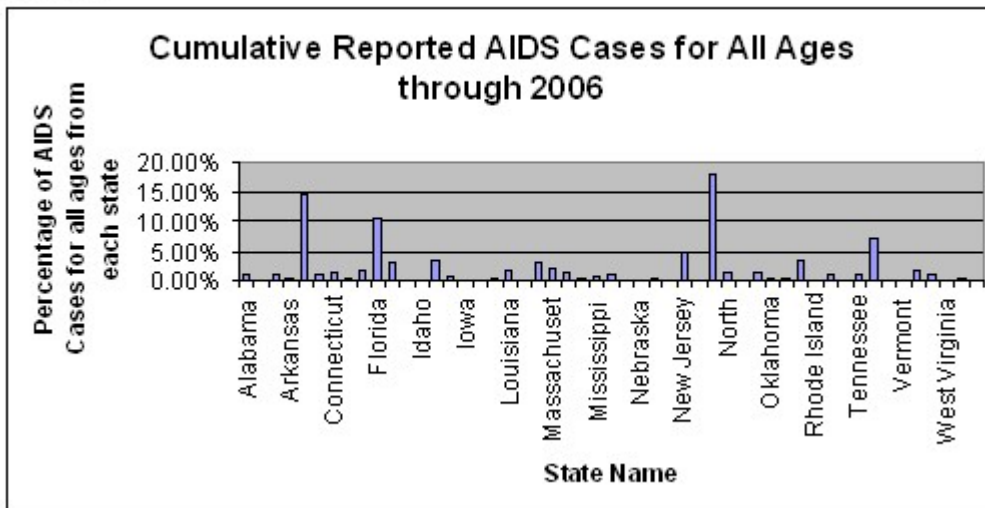
Figure 2

Figure 3

The second half of this unit aligns with the science, technology, and society task that is covered during the latter part of the unit. The students will call upon the graphing unit that was introduced to them at the beginning of the year as they are introduced to population pyramids. The students will develop their skills in analyzing the growth patterns of human populations using population pyramids provided by the Center of Disease Control and Prevention and then distinguish between a developed and underdeveloped country of their choice from the database containing population pyramids.

Science is fueled by data acquisition and in order to narrow the topic the students will examine data related to factors that influence the incidence and prevalence of infectious diseases affecting the growth of human populations. In the second portion of the unit, the students will recall their knowledge of genetics by reviewing dominant versus recessive traits. The students will collect data on the phenotypes of the individuals in the classroom that have either a dominant or recessive trait. The class data will reflect a sample population and the students will then transform their data into an appropriate graphical display recalling the various graphics we discussed from the first section on graphing. The following are a list of some classic dominant traits that I would use with the class.

1. Unattached earlobes are dominant to attached earlobes.
2. A hairline with a widow's peak (my students call this an "eddy") is dominant over a continuous hairline.
3. Mid-digit hair on the middle portions of your fingers is dominant over having no mid-digital hair at all.
4. Rolling your tongue into a tube is dominant to not being able to roll your tongue.
5. Clasping your hands naturally and having your left thumb rest on top of your right thumb is dominant to right thumb over left.
6. The distal end of your pinky bending in towards the ring finger when placing your hands at rest on a table is dominant over a pinky that stays straight (Starr, 2004).

Students will utilize and enhance their skills in generating a bar and a line graph using the class data. The students will then be introduced to software programs that are capable of generating graphical displays. There are a variety of spreadsheet software programs capable of generating charts. The ability to manipulate data through a spreadsheet program is an essential skill that all students should have mastered in order to be fully prepared for the demands of a liberal arts or technical college. Below I have provided an example of a bar graph (Fig. 4) that I generated by entering fictional data on dominant versus recessive traits in a spreadsheet program.

Figure 4
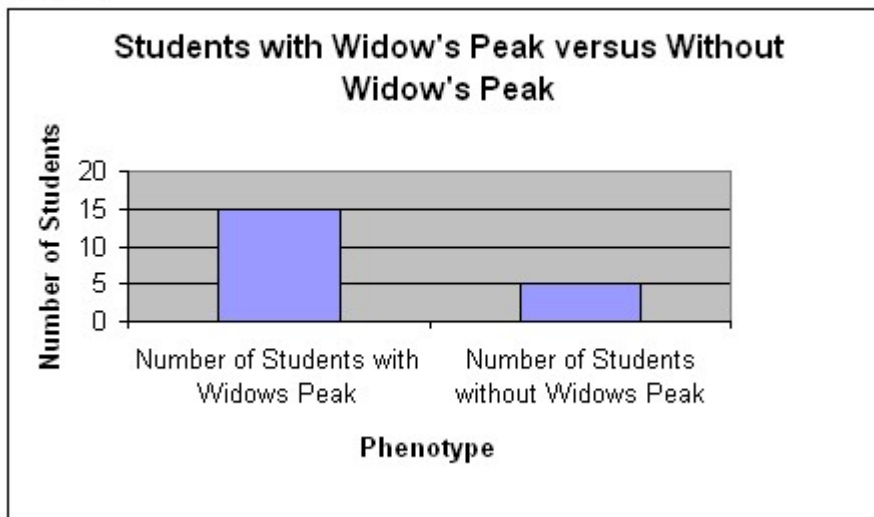
This unit is intended to meet the requirements for biology students at the high school level, but parts of the unit could readily be used at the middle school level as well in other disciplines such as math, business, and psychology. Many computers have a spreadsheet programs installed along with their main word processing programs. I suggest that if you are unfamiliar with the program offered on the computers in your building that you contact your Information Technology personnel for a tutorial or request a professional development seminar on the subject. The ability to manipulate data within a spreadsheet is a critical skill for both the educator and student in the age of data analysis to assess student learning and the success of a school. The spreadsheet program is a critical piece of this unit, as it will be used in throughout the unit to generate graphical displays.

The second part of the unit will focus on the students investigating the factors related to HIV/AIDS that affect the growth of human populations. The science, technology, and society (STS) task from the state requires students to analyze population pyramids representing human populations from developed and underdeveloped countries. The students are asked to compare and contrast these pyramids and determine what factors contribute to the difference in the demographics and growth of each country. This STS task also requires students to analyze population pyramids representing the populations in twenty years. The unit I have developed is intended to broaden the investigation. This unit also aligns with a previous unit I have written on infectious diseases with an emphasis on viral infections.

The second portion of the unit is intended to begin after the students have completed the state STS task on population pyramids. Once the students have practiced collecting data on their class concerning dominant and recessive traits and choosing the appropriate graph to depict the class data, the students will be reintroduced to the STS task on population pyramids. The students will review the how to analyze a population pyramid and the distinct shape a developed country has versus an underdeveloped country. The students will

then choose a developed and underdeveloped country to research the effect that HIV/AIDS has on these countries. Infectious diseases always hold the attention of the students as they are always curious about their health and the various "facts" they believe about the transmission and prevention of more notable infectious diseases. All of humanity is linked in their ability to understand pain and suffering that comes from an infectious disease.

There are many pros and the cons to globalization. The advent of globalization has provided a highway for infectious diseases to travel from country to country. Infectious diseases are capable of spreading to many more populations due to the increased air travel. I want the students to understand that as they research two different countries that may be thousands of miles apart; these countries can easily be linked globally through the ease of traveling by air.

The students will then choose several factors (such as access to healthcare, access to contraceptives, drugs/treatments, and clean water) contributing to the transmission and prevention of HIV/AIDS affecting the growth of a developed and underdeveloped population. The students will use various credible Internet resources such as the World Health Organization, Center for Disease Control, and the United Nations to collect data on their chosen countries. Research on the Internet will provide the students with data related to factors contributing to the transmission and prevention of HIV/AIDS affecting the countries they have chosen to investigate. There have been many gains in the health field in concerning biotechnology and computer technology. These technological advances have allowed for greater access to data monitoring the health of human populations around the world. The students will develop graphical displays of the data using a spreadsheet software program. The students will then compare their graphs with the population pyramids of their countries. The students will compare and contrast how the data are related to population pyramids provided by the U.S. Census Bureau International Database. The students will present their findings to the class through a computer-generated presentation.

Appendix

Implementing District Standards

There are two key standards covered in this exploration of graphing and the influence HIV has on the health and growth of human populations. In accordance with district standards, the students will develop their scientific numeracy skills in presenting scientific data and ideas through graphical displays. The unit will involve teaching students how to appropriately collect and analyze data through graphical displays. The New Haven district requires that students are able to develop an answer as to how science and technology in society affect the quality of human life. In addition, the students will be able to determine how technological advances have increased the longevity of human life and in turn increased the size of human populations over the past century due to the development of vaccinations. The unit will also have a significant e-learning component that will allow the students to use software programs and websites that provide students the ability to manipulate data through various programs offered online and software programs.

Create Graphs Using Spreadsheet Programs

Creating graphs using a spreadsheet program is a simple process once you are familiar with the icons used by the program and where to look for tools located within the toolbar of the program. My instructions are based

on having your data already entered into the spreadsheet. The first column of data you entered will be the "x range" of data and this will appear on the horizontal axis. The second column of data you entered will be the "y range" of data and this will appear on the vertical axis. Using the mouse, "highlight" the two columns of data you entered. For example, place the cursor in cell A2 then "left click" and hold while dragging the mouse to cell B6, then "release" the left click on the mouse. Next, move your mouse to the main tool bar and "left click" on INSERT then select CHART or you can click on the icon showing a bar graph in the tool bar. Step one-- CHART TYPE appears, and under CHART TYPE select the type of graph appropriate from the list of standard types of graphs. You can see a sample view of the graph from the chart type you have chosen by clicking on the box in the lower right hand corner labeled as PRESS TO VIEW SAMPLE. Then "left click" on NEXT. Then, the second step -- CHART SOURCE DATA will appear, "left click" on NEXT. The third step, CHART OPTIONS will appear under TITLES provide a CHART TITLE, a VALUE for x-axis, and a VALUE for the y-axis. You can also determine the number of GRIDLINES you want for each axis. You also have the option for have a LEGEND to show for your data simply by checking the box. There may be an option to show the data table along with your graph by selecting that box. Once you have made your selections, then "left click" NEXT. The last step may provide you with the option of placing your chart in a new spreadsheet or placing your chart in with your data table. If you desire to have your graph or chart placed into a word document then just "right click" and then select COPY, and then "right click" and select PASTE wherever you want your graph to appear in your document.

Examples of Independent and Dependent Variable Identification Statements

The following are different examples of problem statements I would provide to the students to help them practice identifying the dependent and independent variables.

1. Students are investigating the effect of different types of soil on the growth of plants.
2. Students are investigating the effect of various temperatures of seawater on the growth of fertilized sea urchin eggs.
3. Students are investigating the effect of different concentrations of the enzyme pepsin on producing apple juice from apples.
4. Students are investigating the effect of different wavelengths of light on the production of oxygen by red algae.
5. Students are investigating the effect of different types of nutrient sources on the growth of *Streptococcus mutans* .

Sample Lesson

Lesson: Outbreak of a fictional infectious disease

Lesson description: The students will use their creativity to create a fictional disease that is spreading through the school's population. Students will collect data regarding the spread of the fictional disease and will first develop a choropleth map depicting the incidence of the fictional disease throughout the school building. Once

the map is completed, the students will then take the data develop an appropriate data table to organize their data before choosing the correct graph to analyze the data at the end of the unit.

Objective: Engage students by the creation of a fictional infectious disease that is overtaking the student population at our high school.

Opening Engagement Activity: Students look for a number under their desk that indicates whether they have been infected. The Glowing Germ lotion is spread throughout the room without the students' knowledge and I announce that the infectious disease they have just created has struck the classroom. Students examine their hands under a long wavelength UV light to determine if they have been exposed to the disease and determine how much they have been exposed based on how much lotion is on their hands. To simulated the spread of the disease in classrooms across the building the students will choose numbers from a hat to determine the number of cases of the disease found in each class and chart their data in a data table developed by each student

Learning Activity: Students collect fictional data and create an appropriate data table to organize their data in suitable format for a choropleth or map chart. On a large piece of butcher paper, I will have previously recorded the number of students in each grade and the number of staff and faculty in the building. I will ask for a volunteer and have the student come pick a number for a bag of numbers that will serve to represent the number of cases of the fictional infectious disease that will break out throughout the school each day of the unit. The students will record this data in a table they have generated in small groups and create their own map of the building only depicting classrooms in order to simply the shape of the building. The students will use their notes on chorolpleth maps and the sample " World Map of HIV cases" to create their own choropleth map of the infectious outbreak in the school at the end of the unit when all of the data has been collected on the spread of the fictional disease. I will then discuss the key vocabulary words of prevalence and incidence with the students in developing their knowledge of key vocabulary used in epidemiological studies.

Teacher Bibliography

Campbell, L., Campbell B., & Dickinson, D., (2004). *Teaching and Learning Through the Multiple Intelligences.* Boston: Pearson. Reviews each of the intelligences and provides activities for each.

Chambers, J., Cleveland, W, Kleiner, B. & Tukey, P. (1983). *Graphical Methods for Data Analysis* . Wadsworth International Group & Duxbury Press. Provides background on various graphs and criteria for effective versus misleading graphs.

Cothron, J., Geiese, R. & Rezba, R. (2000). *Student and research: Practical strategies for science classrooms and competition* Kendall/Hunt Publishing Co. Provides great sample lessons and creative ideas on teaching scientific investigations through data acquisition.

Cleveland, W. (1993). *Visualizing data* . AT&T Bell Laboratories, Murray Hill, N.J. Provides background on various graphs and criteria for effective versus misleading graphs.

Estimated HIV Infection and Reported AIDS Cases, Year-End. (2006). World Almanac & Book of Facts, 00841382, 2008. Provides statistics on HIV/AIDS cases.

Garrett, L. (July/Aug, 2005). *The lessons of HIV /AIDS. Foreign Affairs.* The Council of Foreign Affairs. Retrieved June 16, 2008 from World Wide Web http://www.foreignaffairs.org/20050701faessay84404/laurie-garrett/the-lessons-of-hiv-aids.html. Excellent article reviewing all angles that HIV/AIDS touches in a country dealing with a large population infected with HIV.

Jelen, B. (2007). *Charts and graphs for Microsoft Office Excel 2007* [electronic resource]. Indianapolis, Ind,: Que, Online book providing tutorial on using Microsoft's Excel spreadsheet program.

Pennsylvania Department of Health. (2001). *Health Statistics-Technical Assistance: Tools of the Trade.* Commonwealth of Pennsylvania. Retrieved June 20, 2008 from World Wide Web http://www.health.state.pa.us/hpa/stats/techassist/tools.htm. Provides background information and examples of statistical measurements, data analysis, charts and graphs, data collection/processing as related to populations.

Phillips, J., & Murray, P., Kirk, P. (2001). *The Biology of Disease* . Oxford: Blackwell Science Ltd. College level pathophysiology text book. Provides introduction to epidemiology.

Robbins, N. (2005). *Creating more effective graphs* . John Wiley & Sons, Inc., Hoboken, NJ. Brief descriptions of various types of graphs and provides various examples and explanations of poor/misleading graphs.

Rugg, H. (1925). *Primer of graphic and statistics for teachers* . Houghton Mifflin Co., Boston, MA. Provides more a historical background of various graph types and their use since this was published in 1925 and some graph types present today were not yet invented.

Schmid, C. (1983). *Statistical Graphics: Design Principles and Practices* . John Wiley & Sons, Inc. Provides overview of the various types of graphs and critiques their uses providing numerous examples of various graphs and poorly constructed graphs. Great section on population pyramids as histograms.

Starr, B. (2004). *Ask a Geneticist. The Tech: Understanding Genetics* . The Tech Museum of Innotvation. San Jose, CA. retrieved from http://www.thetech.org/genetics/ask.php?id=22 Provides examples of human dominant and recessive traits and an image of HIV attacking a white blood cell.

Tortora, G. & Funke, B. (2002). *Microbiology: An Introduction.* San Francisco, CA, Benjamin Cummings. College level textbook with an introduction to epidemiology and background on HIV transmission.

Tufte, E. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, CT. Excellent overview of the purpose of graphs, how they can be misused, what a terrible graph looks like, along with excellent examples of various graphs and their evolution of the years.

United Nations, (2003). *Ageing populations: opportunities and challenges for Europe and North America / United Nations Economic Commission for Europe* . New York: United Nations, 2003. v, 25p. ; 21 cm. Review of the change in demographics and the need for preparation for the larger portions of the developed countries that are ageing.

Websites on Graphing

http://www.statcan.ca/english/edu/power/ch9/first9.htm

Provides examples and defines various types of graphs and provides lesson plans. Examples of bad graphs are under "When is it not appropriate to use a graph?"

http://exploringdata.cqu.edu.au/read_me.htm

Teacher from Education Queensland provides data exploration downloadable files of sample data sets, graphs, assessments, and activities.

http://www.health.state.pa.us/hpa/stats/techassist/tools.htm

Pennsylvania Department of Health provides explanations of statistical tools used in analyzing health of populations.

http://www.mste.uiuc.edu/courses/ci330ms/youtsey/lineinfo.html

Devoted to providing example and defining various types of graphs.

http://www.mathleague.com/help/data/data.htm

Provides examples of line, bar, pie, and mean, median, and mode

http://www.eia.doe.gov/neic/graphs/preface.htm

Provides data on energy and using various types of graphs

http://math.youngzones.org/stat_graph.html

Provides examples of bar graph, line graph, line plot, histogram, pie chart, pictograph, stem and leaf plot, scatter plot, box plot,

Websites with Population Statistics

http://www.prb.org/Content/NavigationMenu/PRB/Educators/Making_Population_Real/Making_Population_Real__New_Lesson_Plans_and_Classroom_Activities.htm

Provides lesson plans and classroom activities on population dynamics.

http://www.bls.gov/bls/demographics.htm

U.S. Department of Labor Statistics Website provides a variety of statistics related to U.S. population

http://www.census.gov/ipc/www/idb/

U.S. Census Bureau International Database Website provides population pyramids of various countries.

http://www.census.gov/dmd/www/teachers.html Web page devoted to providing resources and lessons for teachers on using census data.

http://www.learner.org/interactives/dailymath/getpicture.html

Provides description and examples of exponential population growth and

http://www.hivaidssurveillancedb.org/

HIV/AIDS Surveillance Database Can create custom reports investigating the various demographics and strains of HIV affecting various human populations globally

http://www.cdc.gov/nchs/Default.htm

National Center for Health Statistics for CDC Joint United Nations Programme on HIV/AIDS HIV/AIDS and Human Development Thematic Guidance Notes. Provides details on strategies for HIV/AIDS epidemic

http://www.nlm.nih.gov/medlineplus/infectiousdiseases.html

MedlinePlus: Infectious Disease website from National Institute of Health provides criteria for HIV infection and its development to AIDS.

http://www.gapminder.org/world/

Website that provides data concerning life expectancy, income, infant mortality in graphical displays for countries around the world.

Websites on HIV/AIDS Statistics

---

http://www.who.int/whosis/en/

World Health Organization Statistical Information System Website provides interactive and downloadable health related datasets on various indicators from 193 countries.

http://www.cdc.gov/hiv/topics/surveillance/resources/reports/2006report/pdf/2006SurveillanceReport.pdf

HIV/AIDS Surveillance Report: Cases of HIV Infection and AIDS in the United States, 2006, National Center for HIV, STD and TB Prevention, Centers for Disease Control and Prevention, Department of Health and Human Services, 2008. Provides statistics on HIV/AIDS in U.S. for 2006.

http://www.statehealthfacts.org

Provides downloadable data on HIV/AIDS for each state in U.S.

http://www.cdc.gov/nchhstp

National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention. Provides information on HIV/AIDS and STD infections.

http://www.africaalive.org/facts1.htm

Website devoted to getting teens involved with HIV/AIDS epidemic.

http://www.dedham.k12.ma.us/webquest/fall2000/mb/worldpop.html

Lesson with sample rubrics for generating graphs, links to how population data is collected

http://www.rho.org/html/hiv_aids_progexamples.htm

Non profit organization that provides examples of programs that are providing information and data on educating developing nations about HIV/AIDS

http://www.nfid.org/

National Foundation for Infectious Disease Website provides information on HIV/AIDS infections.

Websites with HIV images

http://www.thetech.org/genetics/index.php

Website from Tech museum of innovation provides great image of HIV virus infecting a white blood cell along with great information on genetics (dominant vs. recessive traits).