# TEAM PROJECT REPORT

# Enhanced Decision Making Emulating Human Reasoning

### Submitted To

### The RET Site

### For

### “Challenge-Based Learning and Engineering Design Process Enhanced Research Experiences for Middle and High School In-Service Teachers”

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### Abstract

### This research looks into the use of an artificial intelligence to determine the shortest and most efficient route for a travelling salesman to take.  The artificial intelligence relies on a genetic algorithm to determine the best route to take.  The goal of this research project is to take a slow genetic algorithm and optimize the algorithm so that it takes less time to function.  Our question is about creating a hybrid genetic algorithm to hasten the processing time.  Can a hybrid genetic algorithm be created that will minimize the processing time?  A genetic algorithm is a binary code that models natural selection in evolutionary theory by crossing over code to create a new solution.  The methods used are classical research using books internet and with assistance from the assigned graduate student.  The results that are expected are that a hybrid algorithm can be produced that will minimize the processing time for the genetic algorithm.  The average speed it takes for a number of cities to be crossed by a set number of generations then the hybrid will be applied to the code and the average speed will be taken given the same constraints.  The scientific conclusions we hope to draw are that a genetic algorithm can be used in conjunction with another type of programming in order to create a more optimized system that is both accurate and time efficient.  This research project hopes to conclude that this is possible and prove it.

### Key Words

Genetic Algorithms, Optimization, Two-Opt, MATLAB, Traveling Salesman Problem.

### Main Body

#### INTRODUCTION

The Travelling Salesmen Problem has been under debate for decades. This problem asks which route will allow a travelling salesman to visit as many people as possible in the shortest amount of time. The concept has been discussed for years as to how this problem is best solved. Even today, there is no one set best method for solving the travelling salesman problem.

Artificial intelligence is one answer that is being explored as a solution to the travelling salesman problem. There are a host of artificial intelligence methods. The artificial intelligence that is being explored within this paper is genetic algorithms and two-opt.

Genetic algorithms (GA) mimic evolutionary processes in order to create a new solution. Solutions are encoded as genotypes. Two of these solutions are chosen and merged, using information from both of the parent solutions in order to form two children. These children are actually coded solutions, their genotypes are decoded and the distance is measured. If the child’s solution has a lesser distance than the parent, then the parent is removed and the child is used as the next parent. If the parent has a lesser distance than the child, the child is removed and that parent stays as a possibility.

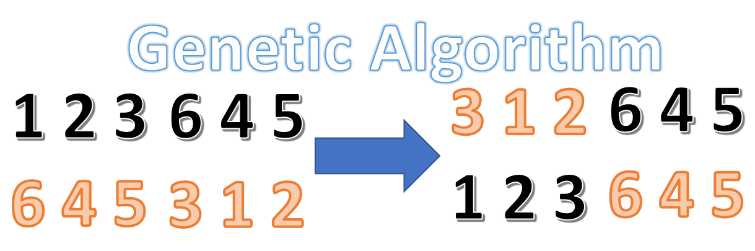
In nature, those that have adapted to survive an environment are successful and are able to sire more offspring. Those that are not suited to an environment or do not adapt fast enough, are left behind. The ability for an organism to survive. This is the concept behind the GA. As each child is created, it is tested against its parents to see if it has better fitness.

Figure 1. Sample of Genetic Algorithm logic using two parents to create children.

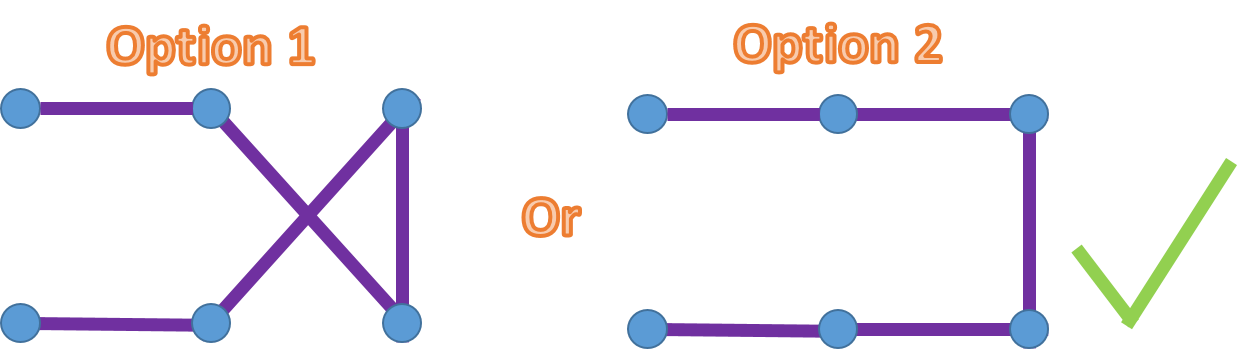
Two-opt is another type of artificial intelligence where the computer is given a set of points, in this case, and two choices per point. The computer finds two other points and chooses the one that has the lowest distance then moves on.

Figure 2. Sample of two-opt logic.

A flaw of the GA is that it takes a very long time for the artificial intelligence to come up with a solution. In larger problems, it can take hours to complete a set of data. The data is very precise, but the wait time is very long. In two-opt, the artificial intelligence comes up with an answer very quickly, but oftentimes the solution lacks the precision that GAs have.

#### LITERATURE REVIEW

Optimization is not a new problem.  The Traveling Salesman Problem (TSP) was first noted in a German handbook from 1832 (Applegate et al. 2007).  The idea behind the TSP is that given a set of cities, an optimal route is determined that minimizes travel time and cost.  This problem may have been around for a while, but a solution has not.  In fact, the number of solutions to the problem is stated by the equation (*(n-1)!/*2 (Matai et al. 2010). TSP is what is known as an NP-hard problem.  For this type of problem, solutions are determined by algorithms, but it is thought to be impossible to find a solution.  Instead of determining an absolute solution, fuzzy logic used to find an optimal solution. Optimization will allow the option of “allocating scarce resources to the best possible effect” (Chinneck 2000). The way Chinneck explained in his book was that you start with a real-world problem and remove as many irrelevant details as possible. Once the problem has been minimized to the most important elements, algorithms can be applied to determine a solution. The algorithms can be utilized through a computer system which will then need to be verified. The algorithm is verified small-scale; in the TSP, the algorithm would only be applied to ten cities and checked by hand. Once the algorithm has been verified, then it needs to be run through a sensitivity analysis, in which different factors are changed in the problem to determine the impact on the solution. If sufficient results have been obtained, this algorithm can then be used to solve the real-world problem at hand.

Two-Opt is one algorithm that has been applied to TSP to find an optimal solution. TSP looks at all of the city locations (called nodes) and requires that the salesman starts and ends at the same node. Two-opt will “exchange or swap a pair of edges, where n is the number of locations.” Two-opt will then work through a number of cities (generally defined in the function or code) and keep completing swaps to find the optimal route. Once two-opt locates “a tour that cannot be improved with two-opt swaps” or the prescribed number of iterations is reached, the algorithm will stop (Kuang 2012). Two-opt generally works very quickly to find an optimal solution.

Another method that has been used to solve NP-hard problems like TSP are GAs. Dianati et al. described GAs as “evolutionary processes [that] could be applied to engineering problems of optimization” (2002). GAs use the mechanisms and vocabulary in organic evolution and apply them to computer science. A mathematical fitness function is determined to find an optimal solution, and a population of binary code chromosomes is created. From that population, a group of “parent” chromosomes are selected, and using crossover and random mutation, “children” codes are created. The fitness of those children codes are then analyzed and the process begins again (Carr 2014). GAs and evolution strategies can be used to determine solutions to real-world problems such as scheduling machines to perform jobs, robot path planning, task scheduling, car automation, (Dianati et al. 2002) drilling circuit boards, computer wiring, order picking in warehouses, vehicle routing (Matai et al. 2010), and many more. Some of the more advanced optimization problems have attempted to put penalties on the fitness of the children codes. In this way, just like humans are able to select the best traits that they want passed down in race horses, cattle, and dogs, the best children codes are able to “reproduce” first. The fitness function is varied and helps guide the solution to the most optimal solution (Petridis et al. 1998). GAs find better solutions than other methods, such as two-opt, but generally it takes a while to cycle through all the generations and find the solution.

#### GOALS AND OBJECTIVES

The goal of the research was to find hybrid algorithm between the two-opt algorithm and GA that found a better solution to the TSP than just using GA alone and/or found the solution quicker than using two-opt alone. To achieve this goal, there were four objectives as follows; (1) learn to understand code written in MATLAB, (2) amend and create 2-3 hybrid codes in MATLAB, (3) test the hybrid codes against pre-written two-opt and GA codes, (4) evaluate the data to determine which algorithm gave the best data in the least amount of time.

#### RESEARCH STUDY DETAILS

For this project, both RET teachers needed to begin with familiarizing themselves with the MATLAB software. Both teachers spent considerable time 5-7 days learning the coding mechanisms embedded within the software and how the codes are used in order to run the different algorithms.

Once MATLAB was understood, then the team was able to look at different algorithms and how those algorithms work. The first algorithms that were tested were two-opt and MY\_GA, which is a GA. These algorithms were applied to the Traveling Salesman Problem (TSP).

**4.1 Single TSP**

Let N = {1,2,3, … , n-1, n} be the set of indices defining the targets and dij be the distance between the ith and jth targets. The problem is assumed to be symmetric so that:  
  
 (1)

It is assumed that the triangle inequality holds true, i.e.

(2)

The TSP can be formulated as an integer linear problem. Let T be a vector that represents the tour.

(3)

(4)

For T to be a tour satisfying the conditions of TSP, T should be of length n+1 with each value in T being unique.

(5)

(6)

The total distance traversed by following tour T is given by,

(7)

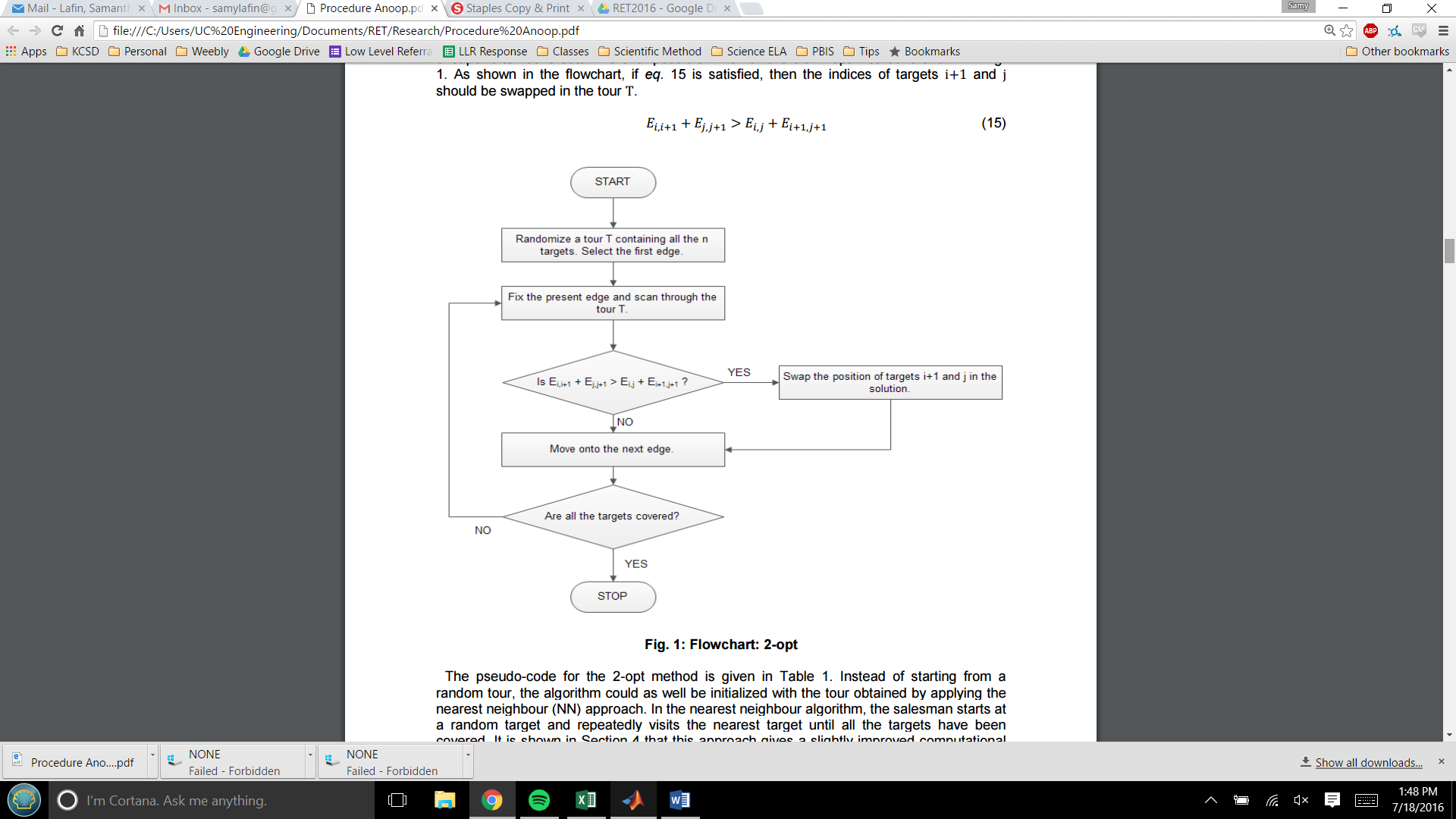
ap and ap+1 are indices of the targets. The total distance traversed, given by D, is the cost function that needs to be minimized. Thus, as the objective is to

(8)

(Sathyan et al. 2015)

**4.2 2-opt method**

The 2-opt method is a simplified form of the Lin-Kernighan algorithm, also known as k-opt. This was developed by Shen Lin and Brian Kernighan. It is basically a tour improvement method which takes a given tour and attempts to modify it in order to obtain an alternative tour of lower cost. A good tour can be obtained by repeatedly replacing sets of your edges by cheaper alternative sets wherever possible. The flowchart of 2-opt method is shown in Figure 3. As shown in the flowchart, if *eq. 15* is satisfied, then the indices of targets i+1 and j should be swapped in the tour T. (Sathyan et al. 2015)



##### Figure 3. Flowchart: 2-opt

The MATLAB coding for the 2-opt algorithm is given in table 1. Instead of starting from a random tour, the algorithm was started from a matrix of 10, 50, 100, or 1,000 cities.

**Table 1. MATLAB Coding for 2-opt Algorithm**

function [optresult, total\_distance] = twoopt(xy,dmat,opt\_rte,num\_iter)

n = size(xy,1); %Set the number of cities

newopt = opt\_rte; %Initial Tour

newopt(n+1) = opt\_rte(1); %Should return to the starting position.

% pfig = figure('Name','Current Best Solution','Numbertitle','off');

for iter = 1:num\_iter,

for i = 1:n-2,

for j = i+2:n,

d1 = dmat(newopt(i),newopt(i+1)) + dmat(newopt(j),newopt(j+1));

d2 = dmat(newopt(i),newopt(j)) + dmat(newopt(i+1),newopt(j+1));

if d1 > d2 %Compare the distances

[newopt(j),newopt(i+1)] = deal(newopt(i+1),newopt(j)); %Swap move.

else

end

% if i == 1,

% newopt(n+1) = newopt(1);

% elseif (i == n)||(j == n)

% newopt(1) = newopt(n+1);

% end

end

end

end

optresult = newopt(1:n);

xy\_opt = xy(optresult,:);

xy\_opt(n+1,:) = xy(optresult(1),:);

distance = 0;

for ii = 1:n-1,

distance = distance + dmat(optresult(ii),optresult(ii+1));

end

total\_distance = distance + dmat(optresult(1),optresult(n));

**4.3 Genetic Algorithm (GA)**

GA is a computer code that simulates the process of biological evolution. Through a fitness function, a parent group of chromosomes is selected. The group undergoes variation through crossover and random mutation to create a child group of chromosomes. Crossover in the algorithm is different because two individual chromosomes cannot be crossed, due to possible repetition in the child code. In this case, one parent code is used and the crossover switches two sections of that chromosome. That child population is then selected for those with the best fitness and the cycle begins again. GA has been found to give optimal solutions in a variety of situations. (Sathyan et al. 2015)

**Table 2. MATLAB Coding for GA**

n = 1000; % Number of cities

load xy1000.mat % locations of the cities

options = gaoptimset('PopulationType', 'custom','PopInitRange',[1;n]);

options = gaoptimset(options,'CreationFcn',@create\_permutations, ...

'CrossoverFcn',@crossover\_permutation, ...

'MutationFcn',@mutate\_permutation, ...

'Generations',5000,'PopulationSize',5000, ...

'StallGenLimit',50,'Vectorized','on');

numberOfVariables = n;

for i = 1:50

tic

a = meshgrid(1:n);

cities = xy(:,2\*i-1:2\*i);

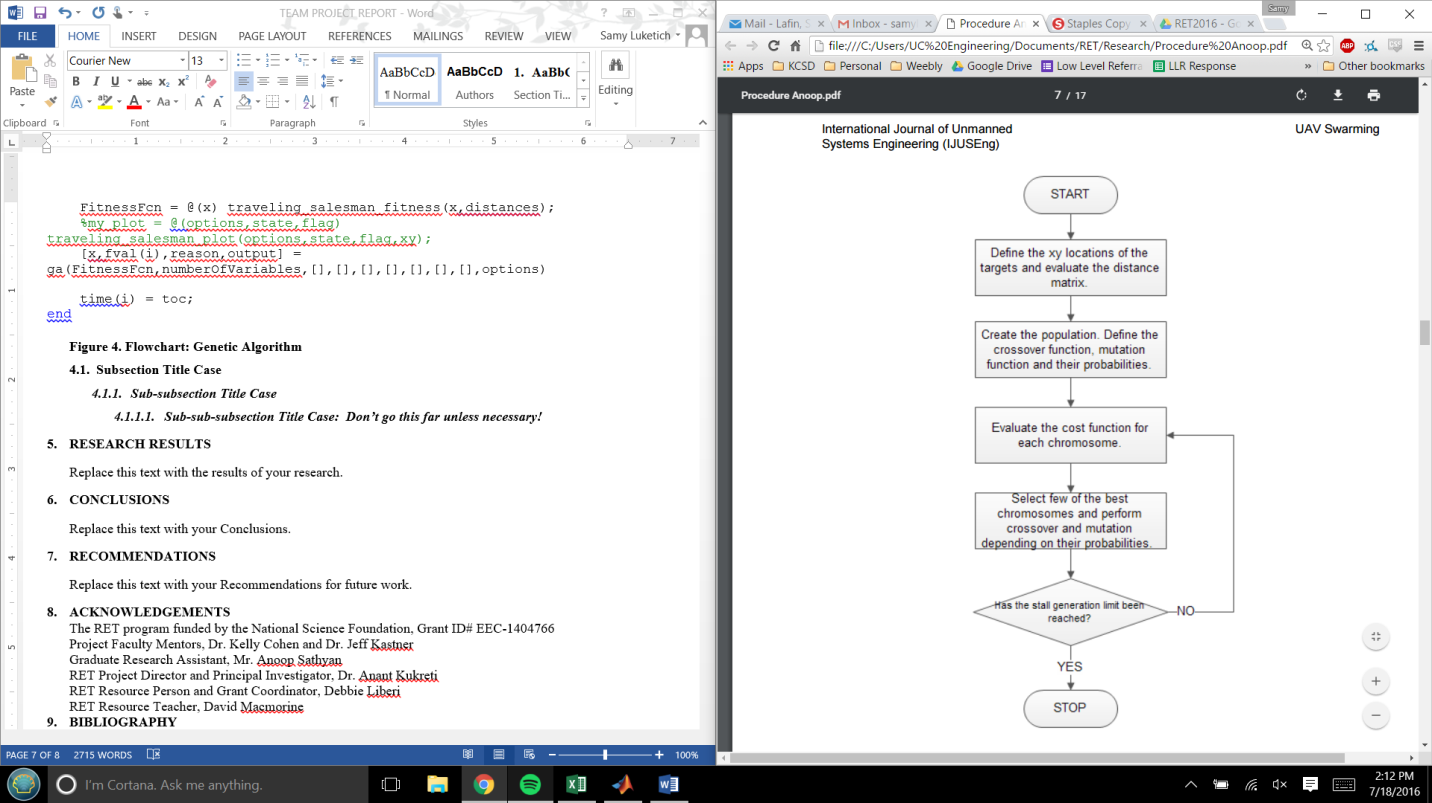
distances = reshape(sqrt(sum((cities(a,:)-cities(a',:)).^2,2)),n,n); %distance matrix

FitnessFcn = @(x) traveling\_salesman\_fitness(x,distances);

%my\_plot = @(options,state,flag) traveling\_salesman\_plot(options,state,flag,xy);

[x,fval(i),reason,output] = ga(FitnessFcn,numberOfVariables,[],[],[],[],[],[],[],options)

time(i) = toc;

end

**Figure 4. Flowchart: GA (Sathyan et al. 2015)**

**4.4 Modified 2-opt**

The second of the hybrid algorithms to be implemented was a modified 2-opt. Whereas 2-opt looks at only two options of edges between four points, the modified two-opt would consider a third pair of edges, with the goal of using this algorithm to quickly locate a shorter distance.

**4.5 Nearest Neighbor**

The first of the hybrid algorithms to be implemented was the Nearest Neighbor addition to the GA. The goal of Nearest Neighbor is to identify the nodes closest to the node under investigation, and map the route through the closest node, as long as no node is repeated twice. The Nearest Neighbor solution is being used as one of the individuals in the population.

**4.6 Nearest Neighbor with Crossover**

In this hybrid, the Nearest Neighbor algorithm is being used as a crossover. Random cities are chosen in one chromosome, and the Nearest Neighbor operator is performed on only those cities. The closest cities are then placed back into the parent chromosome, which then becomes the child. The algorithm will randomly choose between the Nearest Neighbor operator or the flip every time the crossover function is involved.

#### RESEARCH RESULTS

The data gathered from two-opt showed that in a small setting of 10, 50 and 100, the time it took to finish was less than a second. The slowest iteration was 0.09 seconds with 100 cities. By comparison, the GA was somewhat slower by comparison at 0.1 seconds at its slowest iteration of 100 cities. The distance is about the same with 10 and 50 cities between GA and two-opt. As the number of cities increases, the GA slows down significantly. The two-opt can come to a conclusion much faster than the GA (see Figure 5).

**Table 3. Raw Data for GA TSP Testing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genetic Algorithm | 10 cities | | 50 cities | | 100 cities | | 1000 cities | |
|  | Distance | Time | Distance | Time | Distance | Time | Distance | Time |
| Mean | 2.86029 | 0.1890 | 6.00734 | 0.90956 | 8.40377 | 4.1621 | 55.5831 | 111.218 |
| Standard Error | 0.0387 | 0.0127 | 0.04921 | 0.01628 | 0.054325 | 0.0881 | 0.11716 | 0.83248 |

**Table 4. Raw Data for Two-Opt TSP Testing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Two-Opt | 10 cities | | 50 cities | | 100 cities | | 1000 cities | |
|  | Distance | Time | Distance | Time | Distance | Time | Distance | Time |
| Mean | 2.88078 | 0.00058 | 6.06883 | 0.00228 | 8.52074 | 0.01324 | 41.3949 | 21.0273 |
| Standard Error | 0.0403 | 0.00036 | 0.04747 | 0.00011 | 0.04973 | 0.000422 | 0.41897 | 0.398225 |

The distances are comparable until 100 cities where two-opt has a slightly better distance. The real change comes with 1000 city iterations where it may appear that two-opt has the best distance, but the standard error is very high with a 59% confidence value. The GA has a higher distance but gives a confidence value of 88%. The GA gives a greater distance with greater confidence at greater numbers in distance (see Figure 6). The time for the GA has a very high standard error. The confidence value on the time for GA is approximately 17%.

**Figure 5. Time Comparison: GA and Two-Opt**

**Figure 6. Distance Comparison: GA and Two-Opt**

In Figure 5, the data shows that the Two-Opt algorithm finds a solution much quicker than GA. The time increases as the number of cities increases, as there are more cities to evaluate. But for Two-Opt, the data is much more accurate; the data is not spread over a large area, so it is more likely that the Two-Opt algorithm will create a solution sooner than GA. In Figure 6, the distances for the solution each algorithm finds are shown, and what was found was that the Two-Opt algorithm also determined a shorter route for TSP than GA, which was not expected. The error for Two-Opt got quite large as the number of cities increased, so GA is much more accurate.

Modified Two-Opt started off very quick like two-opt but as the cities increased, the confidence value diminished greatly. The time became much higher than two-opt and the confidence value is lower than that of two opt by approximately 18% on the distances.

**Table 5. Raw Data for Modified Two-Opt Hybrid TSP Testing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Modified Two-Opt | 10 Cities | | 50 Cities | | 100 Cities | | 1000 Cities | |
| Distance | Time | Distance | Time | Distance | Time | Distance | Time |
| Mean | 2.90886 | 0.00188 | 6.11674 | 0.03659 | 8.51329 | 0.14772 | 39.2304 | 86.3248 |
| Standard Error | 0.04169 | 0.00046 | 0.04907 | 0.00050 | 0.05300 | 0.00135 | 0.339247 | 0.577607 |

Nearest neighbor tends to be slower, especially with the lower city iterations. The distances are lower overall and the standard error is low. This algorithm was run with the same population and generation parameters as GA. The time has a lower confidence value overall.

**Table 6. Raw Data for Nearest Neighbor Hybrid TSP Testing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nearest Neighbor | 10 Cities | | 50 Cities | | 100 Cities | | 1000 Cities | |
| Distance | Time | Distance | Time | Distance | Time | Distance | Time |
| Mean | 2.86029 | 2.08467 | 5.84137 | 3.71629 | 8.18953 | 5.85383 | 26.2003 | 111.346 |
| Standard Error | 0.03870 | 0.04334 | 0.04141 | 0.12865 | 0.04383 | 0.22609 | 0.053879 | 0.783808 |

Nearest Neighbor with Crossover using GAs starts off with good distance iterations at 10 cities, the time is slow. Time is a major factor with this algorithm, the 1000 city iteration took two and a half hours per iteration which is far beyond the scope of this project and cannot be done within time limits. This algorithm is the most accurate overall keeping in mind the standard error being relatively low.

**Table 7. Raw Data for Nearest Neighbor with Crossover Hybrid TSP Testing**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nearest Neighbor with Crossover | 10 Cities | | 50 Cities | | 100 Cities | | 1000 Cities | |
| Distance | Time | Distance | Time | Distance | Time | Dist. | Time |
| Mean | 2.86029 | 1.78589 | 5.99868 | 39.5981 | 8.43276 | 566.800 | n/a | n/a |
| Standard Error | 0.03870 | 0.02066 | 0.04659 | 0.79879 | 0.05293 | 10.6920 | n/a | n/a |

In Figure 7 below, the distance data is shown for all of the hybrids at 1000 cities, with the exception of the Nearest Neighbor with Crossover, as no data was able to be obtained for that algorithm. What is noted is that the Nearest Neighbor algorithm had the best distance data, even compared to GA. This is important because if this algorithm were being used in a real-world scenario, like the planning of a truck shipping route or unmanned aircraft, it would be best to conserve fuel and battery life by planning the shortest route available. The data for Nearest Neighbor is also not spread out with a large error, meaning the algorithm generally is accurate and precise when coming up with that route. Conversely, Two-Opt has a large spread of data, meaning the algorithm is not as accurate as the number of cities increases.

**Figure 7. Distance Data for GA, Two-Opt, Nearest Neighbor, and Modified Two-Opt at 1000 cities.**

Figure 8 shows the time data for the same algorithms as Figure 7, still at 1000 cities. This graph shows that Two-Opt is still the best algorithm out there for a timed solution. This can be compared to a GPS system used while in route to a destination. If the vehicle is stuck in traffic, and the GPS is utilized to find a different route away from the traffic, a solution needs to be found quickly. In the case of the GPS, the Two-Opt algorithm would be the best out of the tested algorithms to find the new route. Nearest Neighbor is combined with GA, so it is not a surprise that it took a similar amount of time to determine a solution.

**Figure 8. Time Data for GA, Two-Opt, Nearest Neighbor, and Modified Two-Opt at 1000 cities.**

#### CONCLUSIONS

Nearest Neighbor achieved an optimal route at a high cost of time, while Two-Opt solved the problem quickly, but did not give an optimal solution. Nearest Neighbor did determine a lower distance than GA, but if GA had run with a higher population or number of generations, it could have also come up with a similar solution. Two-Opt was known to be very fast initially, so it was not a surprise that it was still the fastest algorithm out of the sample algorithms.

#### RECOMMENDATIONS

The first recommendation for further research is to test the current results on higher numbers of cities. In terms of the specific algorithms, the Nearest Neighbor with Crossover hybrid with GA should be given adequate time to run and obtain results, and then investigate the very high standard error for the time. The final recommendation is to find an equation that will find the optimal number of cities with an optimal number of generations for GA parameters. While it didn’t outwardly seem to impact the research in this study, instead of utilizing trial and error on parameters, it would give future research better understanding of what to use and how to get the best results. Also, this would allow for further comparison of GA and the Nearest Neighbor hybrid.

#### CLASSROOM IMPLEMENTATION PLAN

Matthew’s classroom implementation is as follows. To begin, students will be presented with a breakfast including a variety of fruits that students don’t normally eat, such as cactus fruit. This should allow for curiosity about the fruit, where it comes from and what it tastes like. The hook allows for several senses to be utilized and for natural questions to be asked. This relates to the big idea by having students think about different fruits than the usual fruit that are available. The point is to have them think outside the box about feeding people around the world, who have different climates and biomes than what we have. Students may not realize that fruit is a great and sustainable way to feed many people. After the hook, students will be presented with the challenge of planning and grafting Opuntia cactus. Challenge based learning is taking place in this activity. Students will be implementing, evaluating and communicating the results of their solution that they choose in Activity 3 in this section. The refinement of this process will take place at a later date due to time needed for plant growth. Students will have to answer questions such as, “What types of edible plants can grow in a given USDA zone? Are the edible plants healthy? Any particular health benefits? Can the vascular systems of the plants be connected?” The first lesson for this unit will focus on giving students an understanding of plant morphology. Students will observe different structures within plants that allow homeostasis. Lesson 2 enables students to research different methods of plant propagation. Students will be looking into seed, cutting and grafting propagation techniques. They will also be examining the use of hormones such as Indole butyric acid, Auxin, and Gibberellin. This unit covers the standards relating to the Next Generation Science Standards MS-LS1-4, MS-LS1-5, and MS-LS4-5 which discuss plant structures in relation to reproduction, growth of organisms, and human influence. See Appendix III for the unit and activity templates for Matthew’s plan.

Samantha’s classroom implementation is as follows. The unit that will be implemented is regarding the optimization of the organ donation process. Students will first identify what they already know about the human body, and investigate organ systems in order to gain knowledge about the hierarchy and interconnectedness of the different organ systems. This information will lead students to the big idea of organ donation and the challenge of how to optimize this process to limit wait time and use the least amount of donors for the greatest amount of transplant recipients. In order to complete the challenge, students will have to answer questions, such as “What are organs and tissues that can be donated? Why do some people match and some don’t? Can there be living donors? What makes a ‘good’ candidate to be an organ donor/recipient?” The students will then learn about blood typing and how those different blood types can “match”. Students will also interview a professional connected with the organ transplant process to understand more about how the process works. This unit covers the standards relating to the Next Generation Science Standard HS-LS1-2, which discusses the hierarchy and interaction of body systems. See Appendix IV for the unit and activity templates for Samantha’s plan.

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#### RET Project Director and Principal Investigator, Dr. Anant Kukreti

#### RET Resource Person and Grant Coordinator, Debbie Liberi

#### RET Resource Teacher, David Macmorine

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#### APPENDIX I: NOMENCLATURE USED

NP-hard – a question that can be solved in non-deterministic polynomial time

Two-Opt - an algorithm that exchanges a pair of edges between cities that will stop when a tour is reached that connects all the cities, routes back to the initial point, and when the distance cannot be improved with any further exchanges

Genetic Algorithm – an algorithm that relies on the mechanisms behind organic evolution to find an optimal solution

MATLAB – software for engineers where the testing for this research was completed

Optimization – finding the maximum or minimum value of a function

Traveling Salesman Problem – a question of finding an optimal route for a salesman to travel that starts at one city and ends at the same city. The problem is to find the shortest distance to visit all the cities once and has the least cost associated with the trip.

D – Total distanced travelled by travelling salesman following tour T, whichi, is also the cost function

dij – Distance between the ith and jth targets

Ei,j – Length of the edge connecting the targets in the ith and jth tour T

n – Number of targets

N – Set of indices defining the targets

T – Vector representing the tour

#### APPENDIX II: RESEARCH SCHEDULE

#### Week 1: Understand the function and coding in MATLAB

#### Week 2: Begin developing optimization techniques

#### Week 3: Develop hybrid algorithms

#### Week 4: Finish development, begin testing algorithms

#### Week 5: Test hybrid against two-opt and GA

#### Week 6: Finalize data and develop report

#### APPENDIX III: UNIT PLAN FOR MATTHEW BRUNNER

|  |  |  |
| --- | --- | --- |
| **Name:** | **Contact Info:** | **Date:** |
| **Matthew Brunner** | [**Mbrunner@stspp.com**](mailto:Mbrunner@stspp.com) | **06/24/2016** |

|  |
| --- |
| **Unit Number and Title: Unit 1 : Botanical and Horticultural Sciences** |

|  |  |
| --- | --- |
| **Grade Level:** | 8 |

|  |  |
| --- | --- |
| **Subject Area:** | Biology |

|  |  |
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| **Total Estimated Duration of Entire Unit:** | 2 weeks |

**Part 1: Designing the Unit**

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| 1. **Unit Academic Standards (**Identify which standards:NGSS, OLS and/or CCSS.Cut and paste from NGSS, OLS and/or CCSS and be sure to include letter and/or number identifiers.**):** |

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| --- | --- | --- |
| **MS-LS4-5.** Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.   |  | | --- | | **MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. |  |  | | --- | | **MS-LS1-4.** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. | |

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| 1. **Unit Summary** |

The Big Idea (including global relevance):

Feeding the world. ­­­­­­­­­­­­­­World hunger is something that affects everyone and is not likely to go away anytime soon. Creating plants that provide food and can survive in different zones would be very helpful for people who live in different areas.

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge):

Can different species of cactus be grafted to other cactus within the same genus?

**Are there alternatives to genetically modifying plants to improve their usefulness to humans?**

**Are the edible plants healthier than plants that grow in this region?**

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| 1. **Unit Context** |

Justification for Selection of Content– Check all that apply:

☐ Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.

☐ Misconceptions regarding this content are prevalent.

☐ Content is suited well for teaching via CBL and EDP pedagogies.

☐ The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)

☐ Other reason(s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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The Hook: (Describe in a few sentences how you will use a “hook” to introduce the Big Idea in a compelling way that draws students into the topic.)

A breakfast including a variety of fruits that students don’t normally eat, such as cactus fruit. This should allow for curiosity about the fruit, where it comes from and what it tastes like. The hook allows for several senses to be utilized and for natural questions to be asked.

This relates to the big idea by having students think about different fruits than the usual fruit that are available. The point is to have them think outside the box about feeding people around the world, who have different climates and biomes than what we have. Students may not realize that fruit is a great and sustainable way to feed many people.

The Challenge and Constraints:

☐ Product **or** ☐ Process (Check one)

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| --- | --- |
| Description of Challenge (Either Product or Process is clearly explained below): | List the Constraints Applied |
| **Successfully connect the vascular systems of one species of Opuntia cactus onto another species of Opuntia cactus. (Grafting)** | **Must use a species in the Opuntia genus of cactus.**  **Must complete the graft within 45 minutes.**  **Students may only be in groups of two.** |

Teacher’s Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

**What types of edible plants can grow in a given USDA zone?**

**Are the edible plants healthy? Any particular health benefits?**

**Are the edible plants healthier than plants that grow in this region?**

**Can the vascular systems of the plants be connected?**

**Is there any trick to connecting vascular tissue?**

**Are there alternatives to genetically modifying plants to improve their usefulness to humans?**

**What are the incentives to using cactus fruit over regular fruit?**

**Can cactus fruit be grown anywhere in the world?**

How do plant cells function?

What do plants use in order to transport materials throughout their systems?

How do plants reproduce?

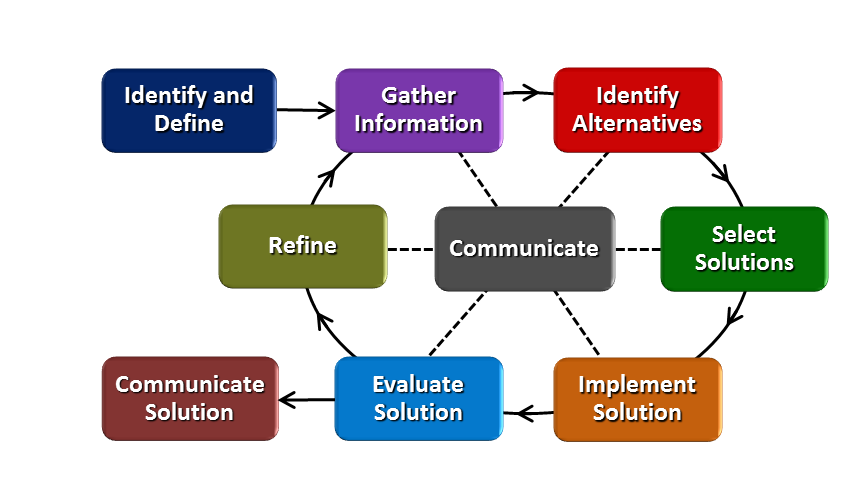
What are the purpose of roots?

Are there different types of roots?

Why are there different types of roots?

Why are there different types of flowers?

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| **4. EDP: Use the diagram below to help you complete this section.** |

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How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

**Students will implement the solution by connecting the vascular tissue of one species of Opuntia cactus to another species of Opuntia cactus successfully. The evidence of success will be that both the cactus scion and host will survive. Students will have a second attempt to optimize their grafting technique for iterative processes.**

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

**Students will create a video to defend their work. Students will be given a rubric for their video.**

What academic content is being taught through this Challenge?

Botany and Horticulture.

Assessment and EDP:

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

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| What EDP Processes are ideal for conducting an Assessment? (List ones that apply.) | List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative. |
| Gather information  Identify Alternatives  Select a Solution  Evaluate Solution  Refine  Communicate Solution | Q/A ☐ formative ☐ summative  Q/A ☐ formative ☐ summative  Q/A ☐ formative ☐ summative  Report ☐ formative ☐ summative  Report ☐ formative ☐ summative  Video Report ☐ formative ☐ summative |

Check below which characteristic(s) of this Challenge will be incorporated in its implementation using EDP. (Check all that apply.)

☐ Has clear constraints that limit the solutions

☐ Will produce more than one possible solution that works

☐ Includes the ability to refine or optimize solutions

☐ Assesses science or math content

☐ Includes Math applications

☐ Involves use of graphs

☐ Requires analysis of data

☐ Includes student led communication of findings

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| **5. ACS (Real world applications; career connections; societal impact):** |

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

|  |  |  |
| --- | --- | --- |
| **Abstract or Loosely Applies to the Real World** | **|--------------------------------------|-------------------------------x--------|** | **Strongly Applies to the Real World** |

Provide a brief rationale for where you placed the X**: ­­­­­­­­­­­­­­World hunger is something that affects everyone and is not likely to go away anytime soon. Creating plants that provide food and can survive in different zones would be very helpful for people who live in different areas.**

What activities in this Unit apply to real world context? Grafting Opuntia cactus to be more resistant to cold.

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

|  |  |  |
| --- | --- | --- |
| **Shows Little or No Societal Impact** | **|-------------------------------------|-------------------------x---------------|** | **Strongly Shows Societal Impact** |

Provide a brief rationale for where you placed the X**: This challenge based learning unit helps to address the concept of providing food to the hungry. It uses techniques that are not normally considered which helps students think outside the box to solve a problem.**

What activities in this Unit apply to societal impact? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.)

General engineering will be covered by guest speaker Eugene Rutz. Specific jobs will be covered via power point.

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| **6. Misconceptions:** |

The plants will “root” into the other plant.

The plant scion will become the same plant as the host.

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| **7. Unit Lessons and Activities: (**Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #’s and Activity #’s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.) |

**Unit 1: Genetically Modified Organisms and their use in Food – Design an alternate method to obtain more than one type of fruit without direct gene manipulation.**

Lesson 1: Plant Adaptations and Human Influence - **(4 days)**

*Lesson 1 will focus on giving students an understanding of plant morphology. Students will observe different structures within plants that allow homeostasis.*

Activity 1: Introduction of the Big Idea, Generating the Essential Question, Challenge and Guiding Questions **(2 days)**

Activity 2: Plant dissection **(2 days)**

Lesson 2: Designing the Challenge

*Lesson 2 enables students to research different methods of plant propagation. Students will be looking into seed, cutting and grafting propagation techniques. They will also be examining the use of hormones such as Indole butyric acid, Auxin, and Gibberellin.*

Activity 3: Methods for Plant Propagation, Explore different Methods of Propagation. Identify and Define, Gather Information, Identify Alternatives, Select Solutions will be done on these days. **(3 days)**

Activity 4: Cactus Grafting, planning and grafting Opuntia cactus. Challenge based learning is taking place in this activity. Students will be implementing, evaluating and communicating the results of their solution that they choose in Activity 3 in this section. The refinement of this process will take place at a later date due to time needed for plant growth. **(2 days)**

CBL: Lesson 2, Activity 4

EDP: Lesson 2, Activity 3 and Activity 4

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| **8. Keywords:** |

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| Plant grafting, biology, horticulture, botany, world hunger, MS-LS4-5. MS-LS1-5. MS-LS1-4. | |
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| **9. Additional Resources:** |

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| **10. Pre-Unit and Post-Unit Assessment Instruments:** |

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| --- | --- |
| **11. Poster** | **12. Video (Link here.)** |

**If you are a science teacher, check the boxes below that apply:**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | ☐ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☐ Obtaining, evaluating, and communicating information |  |

**If you are a science teacher, check the boxes below that apply:**

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

**If you are a math teacher, check the boxes below that apply:**

| **Ohio’s Learning Standards for Math (OLS) or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

**Part 2: Post Implementation- Reflection on the Unit**

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| **Results: Evidence of Growth in Student Learning - A**fter teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.  **Please include**:   * Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.) * An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.) * Other forms of assessment that demonstrate evidence of learning. * Anecdotal information from student feedback. |

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| **Reflection:** Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Instruction sheet. Describe how the actual Engineering Design Process was actually used in the implementation of the Unit. |

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| --- | --- | --- | --- |
| **Lesson Title :** Plant Adaptations and Human Influence | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Grafting Activity Research** |

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| --- | --- |
| **Estimated Lesson Duration:** | **One week** |
| **Estimated Activity Duration:** | **Three days** |

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| **Setting:** |  |

The classroom or lab will be used for the activity. The computer lab will be used for research.

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| **Activity Objectives:** |

Students will learn about the big idea and will generate essential questions.

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| **Activity Guiding Questions:** |

**What are ways to propagate plants?**

**Can any species of plant be grafted?**

**What are the benefits of asexual reproduction?**

**Why would plants use sexual reproduction?**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:** |

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| --- |
| **Activity Procedures:** |

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

|  |
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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| --- |
| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| --- | --- | --- | --- |
| **Lesson Title :** Plant Adaptations and Human Influence | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Grafting Activity Research** |

|  |  |
| --- | --- |
| **Estimated Lesson Duration:** | **One week** |
| **Estimated Activity Duration:** | **Three days** |

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| **Setting:** |  |

The classroom or lab will be used for the activity. The computer lab will be used for research.

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| **Activity Objectives:** |

Students will learn about the big idea and will generate essential questions.

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| **Activity Guiding Questions:** |

**What are ways to propagate plants?**

**Can any species of plant be grafted?**

**What are the benefits of asexual reproduction?**

**Why would plants use sexual reproduction?**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

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| --- |
| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:** |

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| **Activity Procedures:** |

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| --- |
| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| --- | --- | --- | --- |
| **Lesson Title :** Plant Adaptations and Human Influence | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Grafting Activity Research** |

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| **Estimated Lesson Duration:** | **One week** |
| **Estimated Activity Duration:** | **Three days** |

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| **Setting:** |  |

The classroom or lab will be used for the activity. The computer lab will be used for research.

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| **Activity Objectives:** |

Students will be able to construct an argument based on scientific evidence as to how specialized structures of a plant can be used to influence the growth of an organism.

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| **Activity Guiding Questions:** |

**What are glochids?**

**What do cacti fruit taste like?**

**Do all cacti produce fruit?**

**How can one cacti be grafted onto another?**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

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| **Materials**: See Dissection Activity Below |

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| **Teacher Advance Preparation:** |

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| **Activity Procedures:** [**Dissection Activity**](https://docs.google.com/a/stspp.com/viewer?a=v&pid=sites&srcid=c3RzcHAuY29tfG1yLWJydW5uZXItMjAxNnxneDo0YjIwY2M4M2JiYjI1NThl) |

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| --- |
| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| --- |
| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

|  |  |  |  |
| --- | --- | --- | --- |
| **Lesson Title :** Designing the Challenge | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **3** |
| **Activity Title: Grafting Activity Research** |

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| --- | --- |
| **Estimated Lesson Duration:** | **One week** |
| **Estimated Activity Duration:** | **Three days** |

|  |  |
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| **Setting:** |  |

The classroom or lab will be used for the activity. The computer lab will be used for research.

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| **Activity Objectives:** |

Students will be able to construct an argument based on scientific evidence as to how specialized structures of a plant can be used to influence the growth of an organism.

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| **Activity Guiding Questions:** |

**What are glochids?**

**What do cacti fruit taste like?**

**Do all cacti produce fruit?**

**How can one cacti be grafted onto another?**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
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| --- |
| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

|  |
| --- |
| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| --- |
| **Teacher Advance Preparation:** |

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| --- |
| **Activity Procedures:** |

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

|  |
| --- |
| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| --- | --- | --- | --- |
| **Lesson Title :** Designing the Challenge | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title: Grafting Cacti** |

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| **Estimated Lesson Duration:** | **One week** |
| **Estimated Activity Duration:** | **Three days** |

|  |  |
| --- | --- |
| **Setting:** |  |

The classroom or lab will be used for the activity. The computer lab will be used for research.

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| --- |
| **Activity Objectives:** |

Students will be able to construct an argument based on scientific evidence as to how specialized structures of a plant can be used to influence the growth of an organism.

|  |
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| **Activity Guiding Questions:** |

**What types of edible plants can grow in a given USDA zone?**

**Are the edible plants healthy? Any particular health benefits?**

**Are the edible plants healthier than plants that grow in this region?**

**Can the vascular systems of the plants be connected?**

**Is there any trick to connecting vascular tissue?**

**Are there alternatives to genetically modifying plants to improve their usefulness to humans?**

**What are the incentives to using cactus fruit over regular fruit?**

**Can cactus fruit be grown anywhere in the world?**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

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| **Teacher Advance Preparation:** |

[Teacher Guide](https://docs.google.com/a/stspp.com/viewer?a=v&pid=sites&srcid=c3RzcHAuY29tfG1yLWJydW5uZXItMjAxNnxneDoyN2YxYzkxOTM0MTZjN2Rj)

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| **Activity Procedures:** |

[Student Worksheet](https://docs.google.com/a/stspp.com/viewer?a=v&pid=sites&srcid=c3RzcHAuY29tfG1yLWJydW5uZXItMjAxNnxneDozNzFiMzUyMmFmYzEyODZl)

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

#### APPENDIX IV: UNIT PLAN FOR SAMANTHA LAFIN

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| **Name: Samantha Lafin** | **Contact Info: Scott High School – Taylor Mill , KY** | **Date: 08/22/16** |

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| **Unit Number and Title: Unit 1 – Human Body Systems** |

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| **Grade Level:** | 10 |

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| **Subject Area:** | Science - Biology |

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| **Total Estimated Duration of Entire Unit:** | 10 class periods |

**Part 1: Designing the Unit**

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| 1. **Unit Academic Standards (**Identify which standards:NGSS, OLS and/or CCSS.Cut and paste from NGSS, OLS and/or CCSS and be sure to include letter and/or number identifiers.**):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| 1. **Unit Summary** |

The Big Idea (including global relevance): Human Body Systems – organ donation

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge):

How do we effectively & efficiently get the donor organs to the people waiting for a transplant?

How do we use eligibility criteria effectively to determine who gives/receives organs?

How can we minimize the amount of time that it takes for someone to receive an organ?

How can we ensure that as many recipients as possible use as few donors as possible?

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| 1. **Unit Context** |

Justification for Selection of Content– Check all that apply:

☐ Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.

☐ Misconceptions regarding this content are prevalent.

☐ Content is suited well for teaching via CBL and EDP pedagogies.

☐ The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)

☐ Other reason(s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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The Hook: (Describe in a few sentences how you will use a “hook” to introduce the Big Idea in a compelling way that draws students into the topic.)

Students will begin the unit with a silent brainstorm as to what they already know about the human body and the organ systems.

Students will research careers connected to the human body and organ systems, hopefully touching on surgeons, doctors, transplant workers, bioengineers.

Once the organ systems and careers have been investigated, students will watch the following video: <https://www.youtube.com/watch?v=HuKx2a5HkIM> which outlines the organ donation process.

List some well-known people that have participated in organ transplant surgeries, and have students add people to their lists that they know personally (family, friends).

Students will be asked to talk about the pros and cons of the current system, which leads into the challenge of optimizing the donation process. Students will be asked to share personal experiences and find well-known people who have had organ transplants to illustrate the importance of this process.

The Challenge and Constraints:

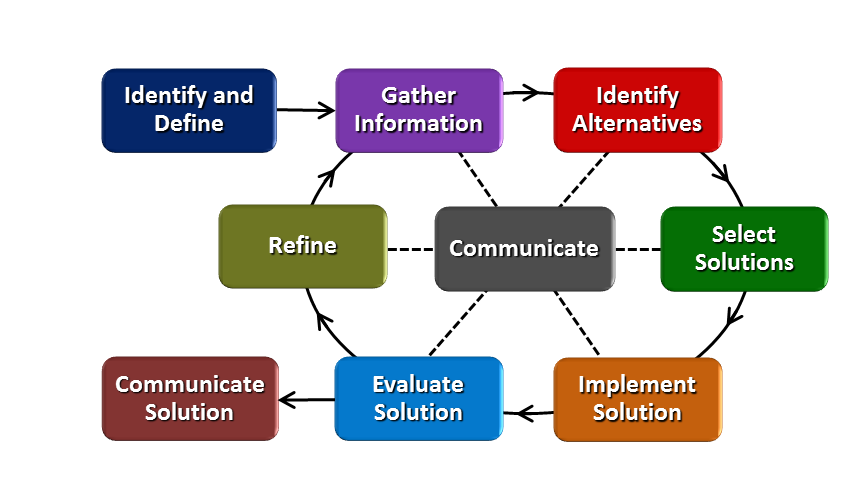
☐ Product **or** ☐ Process (Check one)

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| Description of Challenge (Either Product or Process is clearly explained below): | List the Constraints Applied |
| Students will be asked to create the most efficient and effective way of identifying matching donors and recipients from a list of 15 donors and 15 recipients. Students will only investigate living donors (those that can donate/receive kidneys, parts of lungs, bone marrow, etc) | **Time**  **Knowledge of limiting factors (blood type, donation process)**  **Living donors and types of organs**  **Pool of donors/recipients**  **Treat 12-15 recipients in pool**  **Access to mentors**  **Beginning of school year – I don’t know students, and students may not know each other well yet.**  **Use of statistics to analyze data** |

Teacher’s Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

* What are organs that can be donated?
* Which tissues can be donated?
* How are organs donated?
* Why do some people match and some don’t?
* How is who gets an organ or not decided?
* How long do you have to wait for an organ?
* How are organs transplanted?
* Does someone have to die in order to transplant an organ?
* Can there be living donors?
* Under what conditions can living donors be used?
* What does a donor need to have in order to qualify to be a donor?
* What does a recipient need to have in order to qualify for a transplant?
* What makes a “good” candidate to be an organ donor?
* What makes a “good” candidate to be an organ recipient?
* Why does someone’s blood type matter?
* Why does someone’s body type matter?
* How do you measure “how sick” someone is?
* Is there an age limit to donation?
* Is there an age limit to receive a transplant?
* How many people can a donor help?
* Where is a list of all the organs and tissues that can be donated?
* What if I live too far from my donor?
* How much does organ donation cost?
* Is organ transplant surgery covered by insurance?
* How many people are waiting on the transplant list?
* How could the rest of someone’s body be impacted by a transplant?
* What happens after a transplant physiologically?

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| **4. EDP: Use the diagram below to help you complete this section.** |

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How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

**Students will be asked to design a process (flowchart/system) that gets the most number of organ recipients treated efficiently and effectively. The teams will be asked to treat at least 12 of the 15 recipients with their chart to be an effective list. Students will create an optimization flowchart for organ donation. After creation the students will test the flowchart in their team and then have another team test their flowchart to see if they get consistent results. After testing, students will have a chance to devise solutions to the unforseen flaws in their plan.**

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

**Once all the testing has taken place, students will create a brochure to “sell” their optimization scheme to the class.**

What academic content is being taught through this Challenge?

**Students will look at the hierarchy and interactions of all the components of the human body to determine an optimal scheme for organ donation procedures, by looking at several components of health and the human body.**

Assessment and EDP:

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

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| What EDP Processes are ideal for conducting an Assessment? (List ones that apply.) | List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative. |
| Gather Information  Select Solutions  Evaluate  Communicate | Quiz on evaluative criteria ☐ formative ☐ summative  Rubric ☐ formative ☐ summative  Rubric ☐ formative ☐ summative  Final project and exam ☐ formative ☐ summative |

Check below which characteristic(s) of this Challenge will be incorporated in its implementation using EDP. (Check all that apply.)

☐ Has clear constraints that limit the solutions

☐ Will produce than one possible solution that works

☐ Includes the ability to refine or optimize solutions

☐ Assesses science or math content

☐ Includes Math applications

☐ Involves use of graphs

☐ Requires analysis of data

☐ Includes student led communication of findings

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| **5. ACS (Real world applications; career connections; societal impact):** |

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

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| **Abstract or Loosely Applies to the Real World** | **|--------------------------------------|-------------------------------------X |** | **Strongly Applies to the Real World** |

Provide a brief rationale for where you placed the X**:­­­­­­­­­­­­­­ Students will be working on a real problem that is currently being researched in the medical field.**

What activities in this Unit apply to real world context? **The challenge itself directly applies to real world research, as the activity itself is based on research currently being done in terms of kidney donations.**

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

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| **Shows Little or No Societal Impact** | **|-------------------------------------|------------------------------------- X |** | **Strongly Shows Societal Impact** |

Provide a brief rationale for where you placed the X**: ­­­­­­­­­­­­­­Students working on this problem statistically will be impacted by organ donation at some point in their life, whether they are a donor, recipient, or family member. Their understanding of this process and the difficulties in placing donors with recipients could help increase the organ donation practice and awareness, benefiting society as a whole.**

What activities in this Unit apply to societal impact? **The challenge itself directly has societal impact, as if this system can be optimized, it can improve the quality of life for many in our society.**

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.)

* Guest speakers (either in person or on Skype) from organ donation centers, recipients, donors
* Career research assignment

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| **6. Misconceptions:** |

* Organs that can be transplanted
* Living donors
* Religion does not allow organ transplant (myth)
* There are lots of organs to be donated because lots of people die all the time
* Certain organs cannot be transplanted

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| **7. Unit Lessons and Activities: (**Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #’s and Activity #’s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.) |

Lesson 1: Students will look at the human body as a whole, generating information about the different organ systems, cell types, and tissue types in the body. Students will organize that information into a hierarchy, and then look beyond the body itself to careers and applications dealing with the human body. (4 days)

- Activity 1: Silent brainstorm/Human body jigsaw (2 days)

- Activity 2: Career research (1 day)

- Activity 3: Essential questions, develop challenge (1 day)

Lesson 2: Students will focus on the challenge at hand, and investigate concepts specific to the current transplant system. Students will need to learn about how eligibility requirements are set and met by many parties before being able to determine a system of donating organs that is the most efficient. (6 days)

- Activity 4: Blood Type/HLA (2 days)

- Activity 5: Ask an Expert (2 days)

- Activity 6: Challenge (2 days)

CBL: Lesson 1, Activity 3; Lesson 2, Activities 5 and 6

EDP: Lesson 2, Activity 6

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| **8. Keywords:** |

Transplant, organ, donor, recipient, eligibility, organ systems, hierarchy, human, organ rejection

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| **9. Additional Resources:** |

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| **10. Pre-Unit and Post-Unit Assessment Instruments:** |

Unit 10 pre-assessment

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| **11. Poster** | **12. Video (Link here.)** |

**If you are a science teacher, check the boxes below that apply:**

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | ☐ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☐ Obtaining, evaluating, and communicating information |  |

**If you are a science teacher, check the boxes below that apply:**

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

**If you are a math teacher, check the boxes below that apply:**

| **Ohio’s Learning Standards for Math (OLS) or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

**Part 2: Post Implementation- Reflection on the Unit**

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| **Results: Evidence of Growth in Student Learning - A**fter teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.  **Please include**:   * Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.) * An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.) * Other forms of assessment that demonstrate evidence of learning. * Anecdotal information from student feedback. |

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| **Reflection:** Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Instruction sheet. Describe how the actual Engineering Design Process was actually used in the implementation of the Unit. |

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| **Lesson Title : Human Body Systems** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **1** |
| **Activity Title: Organ System Jigsaw** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. Identify organ systems and components of those systems,
2. summarize the functions of those systems, and
3. construct a hierarchy of the human body based on the components and interconnections of those systems.

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| **Activity Guiding Questions:** |

* What are the different organ systems?
* What components make up each system?
* What is the function of the organ systems?
* How do the organ systems work together?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Poster paper, markers, handout (see attached file)

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| **Teacher Advance Preparation:** |

Prepare large sheets of paper with organ systems titled on them, post around classroom. Provide markers/pens/pencils for students to write on posters

Copy notes pages for each group

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| **Activity Procedures:** |

Day 1:

1. Human Body Silent Brainstorm
   1. Put the title of each organ system on a sheet of paper, and place on tables around the room. \*\*You may need to have 2 sheets per organ system depending on the size of the class
   2. Students will be given 5 minutes (you may increase to 10) to move around and write as much as they know on each organ system sheet
   3. Take pictures of the papers after the activity - they will be given to the teams for the jigsaw
2. Human Body Jigsaw
   1. What is our standard? What are we expected to be able to do? Let’s put that in words we understand
   2. Each team will be assigned an organ system
      1. Fill out notes page (legibly - will be making copies for the class) - DO NOT FILL IN CELL OR TISSUE TYPES
      2. Present information to the class (2-3 minutes)
      3. 3-5 MC quiz questions
   3. How should we grade this? What would be examples of good notes? Bad note? Good presentation? Bad presentation?
      1. What is a good question? When we get stumped, sometimes we say “that’s a good question.” Should good questions be very easy or more difficult to answer?
3. Human Body Jigsaw: team work time
   1. What is a team?
   2. How are you going to break up the work to make it feasible for everyone?
   3. How are you going to get the deliverables to the teacher?

**Exit Slip:** Take 5 minutes to reflect on what we learned today. Make a t-chart. On one side, write ideas we discussed today that you are very comfortable with. On the other side, write questions you still have or something you don’t understand. Your t-chart should not look like anyone else’s t-chart!

Day 2:

1. **Enter Slip:** Write a one paragraph summary of how your team’s organ system functions to keep your body alive.
2. Human Body Jigsaw: 5-10 minutes to finish notes and review with team
   1. At end of time: notes page and quiz questions are due
3. Human Body Jigsaw: Divide and conquer (20-25 minutes)
   1. Break class into 3-4 groups, each group has one member from each team
   2. Each team member gets 2-3 minutes to present their notes to the group
   3. Must explain the components and the function of the system to the class
   4. Notes will be on the board for each group and will be distributed tomorrow to each class member
   5. After mini lecture, students should be able to answer the quiz questions (open-note quiz tomorrow!)
4. Share out - what questions do we have?
5. Look at the standard - how can we now make this a hierarchy? (20-25 minutes)
   1. What do we still need?
   2. What questions do we need to answer?
   3. Divide cells and tissues into previous groups
   4. Find info - present in 10 minutes
      1. Definition
      2. Function
      3. Where it can be found
6. **COLLECT GROUP NOTE SHEETS** - make copies and pass back to students tomorrow
7. **Exit Slip:** Write one sentence about what you did today. Write one sentence explaining why it was important. Write one sentence about where you could use what you did today again. Write one sentence about how well you worked today in class. Write one sentence about what you think the next step should be. Please turn your exit slips to the homework bin.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Quiz questions, walking around to different groups during activity, exit slip

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| **Lesson Title : Human Body Systems** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Career Research** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **1 day** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. List several careers and characteristics of those careers that relate to human body systems and
2. Connect a career to classroom content.

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| **Activity Guiding Questions:** |

* What careers are related to the human body system?
* What types of education do you need to have in order to have one of these careers?
* How much money will you make in these careers?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Mynextmove.org, career worksheet, pop quiz, reading assignment, art supplies to create posters (construction paper, printer paper, colors, scissors, glue sticks)

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| **Teacher Advance Preparation:** |

Create pop quiz with questions that students provided in their groups.

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| **Activity Procedures:** |

1. **Enter Slip:** Add 5 words to the “glossary” page in your notebook (last page of your binder) that you didn’t know before the Human Body Jigsaw yesterday. After that, brainstorm 5-10 careers/jobs that have to have knowledge of the human body, its components, and how it functions.
   1. Share out of jobs - create a list for all students to see
   2. Make sure students are writing down jobs they find interesting or didn’t think of
2. Pass out note sheets
3. MyNextMove.org career worksheet teach
   1. Identify degree levels and years of schooling
   2. Show an example using key words
   3. Clearly explain how to find college information - students can use colleges they are interested in
4. Career Advertisement
   1. Choose one career to “advertise” to the class
   2. Can be created by hand or computer-created
   3. Must include:
   4. Career name
   5. Average Salary
   6. Education Required
   7. Outlook for this career
   8. One college that offers that career path
   9. Price of that college
   10. Classes you will need to take for career path
   11. How this job relates to human body systems
   12. A picture that relates to this career
5. Human Body Pop Quiz
6. After pop quiz, students should work on filling out career worksheets (due at the end of class today), and career advertisement (due at the beginning of class the next day)
7. **Exit Slip:** For homework, you will be reading “Stories about Organ Donation”. For your exit slip, please answer the following questions on a separate sheet of paper and turn them to the homework bin before you leave class.
   1. Read the titles in the passage. What do you think you will be reading about?
   2. Read the titles in the passage. What do you already know about this topic?
   3. How has the information been divided into smaller topics?
   4. What visuals are used? What do they tell me about what I will be reading?
   5. Look at the questions at the end of the section. How do they help guide you as to what you will be reading?

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Pop quiz, career advertisement, enter slip

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| **Lesson Title : Human Body Systems** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **3** |
| **Activity Title: Essential Questions to Challenge** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **1 day** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. Give examples of health-related careers,
2. focus an application of learning the components of the human body to organ donation, and
3. begin to use what they know to create a new organ donation system.

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| **Activity Guiding Questions:** |

* What are careers related to the human body, specifically organ transplantation?
* Who gets organ transplants?
* What is important to know about the organ transplant process?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Summer poster, Hook video: <https://www.youtube.com/watch?v=HuKx2a5HkIM>

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| **Teacher Advance Preparation:** |

None

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| **Activity Procedures:** |

Introducing the Challenge

1. What careers are linked - how are they connected? What patterns are there?
   1. Hook video: <https://www.youtube.com/watch?v=HuKx2a5HkIM>
      1. How does this video relate to the human body?
      2. How does this video relate to our careers?
   2. Who knows someone famous who has donated/received an organ for transplant? Share information about the process. Record information on board.
   3. Who knows someone who has donated/received an organ for transplant? What do you know about the process? Record information on board
   4. What do you know about organ transplants? What do you think is important to know about organ transplants?
      1. 5 min: brainstorm a list in your notebook (include facts, questions, vocab, etc.)
      2. Pick the 4 most important points in your list.
      3. 3 min: Share your 4 points with a partner - combine your lists. Choose the 2 most important from the combination list.
      4. 5 min: Share your 2 points with a group - combine your lists. Choose the 1 most important from the combination list.
      5. Share with class - create a master list
      6. As a class, do you think we are missing information?
   5. What do we need to know - generate 3-5 essential questions
      1. Try to get to: “**How do we effectively and efficiently get the donor organs to the people waiting for a transplant?**”
   6. Introduce the summer poster from RET
   7. Introduce the challenge
      1. Optimization scheme for organ donation
      2. Pool of 15 donors, 15 recipients
      3. Living donors only - what types of organs/tissues?
      4. Treat 12-15 recipients
   8. Now that we know the challenge, what else do we need to know?
2. **Exit Slip:**Write one sentence about what you did today. Write one sentence explaining why it was important (relate this back to your essential questions!). Write one sentence about where you could use what you did today again. Write one sentence about how well you worked today in class. Write one sentence about what you think the next step should be. Please turn your exit slips to the homework bin.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Listen to student responses, gauge discussion based on responses

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| **Lesson Title : Optimizing Organ Donation** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title: Blood and Protein Typing** |

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| **Estimated Lesson Duration:** | **6 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. Identify the different types of blood,
2. explain why blood has a type based on the cell identifiers,
3. demonstrate blood typing in a lab setting,
4. discuss how blood typing can be used to identify a suspect in a murder case, and
5. construct an argument to justify why the suspect is guilty.

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| **Activity Guiding Questions:** |

* What are the different types of blood?
* Why is blood type important?
* What types of blood “match”?
* What parts of the cell identify the blood type?
* Who discovered blood typing?
* How was blood typing discovered?
* Why is it important to know blood type?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Student science notebook, powerpoint with tables for students to copy, blood typing video, blood typing lab materials (see handout)

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| **Teacher Advance Preparation:** |

Create blood samples, create blood testing kits, create sample kits for groups

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| **Activity Procedures:** |

Day 1:

1. **Enter Slip:**Tabletop twitter: You and your group are going to circle around to all the large sheets of paper on the lab tables. You will have to “tweet” to each of the hashtags on that table. All of the hashtags are related to the blood typing video you watched last night. You are not allowed to switch tables until you hear the sound.
   1. Hashtags: Karl Landsteiner, Antigens, Rh Factor, Protein Codes, Blood Donor, Blood Matches
   2. 2 minutes per table
   3. Review and Q&A when finished
2. CSI Lab
   1. Pass out lab handouts
   2. Students read directions, summarize in group, summarize to class
   3. Who is the victim? Who are the suspects? What evidence do you have?
   4. Demo how each station will work.
      1. Take notes
      2. Write observations
      3. Why is it important to write down everything you see?
   5. Students each get a “type test” kit to fill out the chart on the top of the page (10 minutes)
   6. Students get 5 minutes per station
3. **Exit Slip:** Please write down your answers to the three essential questions in your notebook. I will be asking you the answers before you leave class, so be prepared!

Day 2:

1. **Enter Slip:** Take out your labs. We are going to finish all our testing today. Be ready to start as soon as Ms. Lafin finishes attendance and reviewing directions.
2. Finish Lab
3. Blood Typing Lab Reflection - in your notebook, please answer the following questions using complete sentences. You may not use the words “it”, “like”, “thing”, or “stuff”. Pretend you are answering these questions as an expert witness in the trial of the suspect you identified.
   1. How would you improve the blood testing from the crime scene?
   2. Can you elaborate on the reason you think the evidence points to the suspect?
   3. What could be done to minimize errors in the testing of the blood samples?
   4. Suppose you had another sample of blood from the crime scene. What would you do?
   5. Can you formulate a theory as to how the suspect’s blood got to the crime scene?
   6. How could you prove that the suspect was at the crime scene? Would you need only the blood evidence that you have given to the court, or would you need more evidence?
   7. How would you rate the quality of the evidence? Do you think it is enough evidence to convict the suspect?
   8. Based on the evidence presented, do you think the suspect is innocent or guilty? Please explain your answer.

**Reflections are due at the next class period**.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Check tabletop twitter for misconceptions and basic understanding, circulate through groups during lab to identify misconceptions and guide students toward scientific practices, spot-check notebook responses to determine if learning has taken place

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| **Lesson Title : Optimizing Organ Donation** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **5** |
| **Activity Title: Ask an Expert** |

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| **Estimated Lesson Duration:** | **6 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. Organize a list of questions for a mentor interview,
2. Discuss the list of questions with a mentor, and
3. Use this lesson to compose a plan to optimize organ donation.

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| **Activity Guiding Questions:** |

* What do you already know about organ donation?
* What do you need to know about organ donation?
* What are the eligibility requirements for organ donors?
* What are the eligibility requirements for organ recipients?
* What needs to happen during an organ donation?
* What other careers are connected to organ donation?
* Can there be living donors?
* What can be donated in a transplant?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

None

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| **Teacher Advance Preparation:** |

Set up mentor day/time in advance of beginning the unit

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| **Activity Procedures:** |

Day 1:

1. **Enter Slip:** Write what you think the answers are to the essential questions.
   1. Share with a neighbor.
   2. Share as a table.
   3. Share as a class - write ideas on board.
2. Lead in from Enter Slip to Activity
   1. What is our ultimate goal (challenge)?
   2. What do we need to know to get there? List guiding questions on the board
   3. What do we already know? Cross out questions we know the answers to
   4. What can we do to find answers?
   5. Mentors coming tomorrow to answer questions (20 minutes)
      1. ~15-20 questions that you will ask them to help guide you in your challenge
      2. Questions should not have one answer - should be open ended
      3. Brainstorm 3-5 questions to get them started
      4. Can ask other questions that are job-related
      5. Question ideas
         1. Describe your typical workday
         2. What skills are required
         3. What do you find most challenging?
         4. What do you find most enjoyable?
         5. What are the pros of your job? Cons?
         6. How many hours/week do you work?
         7. How would you describe the culture where you work?
         8. Too many/few people entering profession?
         9. What is some research that could benefit what you do?
         10. Who are some important people in your industry?
         11. What is a reasonable salary range?
         12. How did you get your job?
         13. What educational preparation did you do?
         14. What experiences did you have before beginning your job?
         15. What would be good resources to use to find more information on \_\_\_\_\_?
         16. What other career paths are related to what you do?
   6. How should we treat the mentors
      1. Welcoming/greeting
      2. Classroom expectations
      3. What are our expectations for mentors
      4. What should tomorrow look like? Sound like?
      5. If Dr. Sapp walked in, what would we want him to see?
3. **Exit Slip:**Write one sentence about what you did today. Write one sentence explaining why it was important (relate this back to your essential questions!). Write one sentence about where you could use what you did today again. Write one sentence about how well you worked today in class. Write one sentence about what you think the next step should be. Please turn your exit slips to the homework bin

Day 2:

1. **Enter Slip:** Please have your list of questions for your mentors on your desk, along with something to write ***with*** and something to write ***on***.
2. 5 min - prep work with group (allow mentors time to get settled and set up)
3. Mentor interviews
4. **Exit Slip:** Based on what you know and what you have learned from your interviews, please write the answers to the essential questions in your notebook.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Monitor student questions as they are being written, monitor interviews, review exit slips

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

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| **Lesson Title : Optimizing Organ Donation** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **6** |
| **Activity Title: The Challenge** |

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| **Estimated Lesson Duration:** | **6 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Rm 2610, Scott High School** |

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| **Activity Objectives:** |

Students will be able to:

1. Highlight the important concepts in the organ donation process,
2. construct a plan to optimize the organ donation process,
3. compare and contrast different plans to determine which plan works the best, and
4. communicate the results of their plan to the class.

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| **Activity Guiding Questions:** |

* Why do some donors/recipients match and some don’t?
* How is who gets an organ or not decided?
* Can there be living donors?
* What makes a “good” candidate to be an organ donor?
* What makes a “good” candidate to be an organ recipient?
* How many people can a donor help?

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| Asking questions (for science) and defining problems (for engineering) | Patterns |
| Developing and using models | Cause and effect |
| Planning and carrying out investigations | Scale, proportion, and quantity |
| Analyzing and interpreting data | Systems and system models |
| Using mathematics and computational thinking | Energy and matter: Flows, cycles, and conservation |
| Constructing explanations (for science) and designing solutions (for engineering) | Structure and function. |
| Engaging in argument from evidence | Stability and change. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s Learning Standards for Science (OLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| Demonstrating Science Knowledge **(D)** |
| Interpreting and Communicating Science Concepts **(C)** |
| Recalling Accurate Science **(R)** |

| **Ohio’s Learning Standards for Math (OLS) and/or**  **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| Make sense of problems and persevere in solving them | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto precision |
| Construct viable arguments and critique the reasoning of others | Look for and make use of structure |
| Model with mathematics | Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, OLS and/or CCSS):** |

LS 1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Trifold brochure google doc, full page brochure google doc, computers

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| **Teacher Advance Preparation:** |

Prepare google docs, prepare rubric for grading

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| **Activity Procedures:** |

Day 1:

1. **Enter Slip:** Identify ***at least*** 4 constraints (limitations) that you will have to work with when creating your plan
2. Optimize organ donation plan
   1. Identify the essential question again
   2. Make sure students have all the research out and with their group
   3. Pass out the donor/recipient pool worksheets
   4. Goal: Get the most recipients to receive the necessary organs (at least 12!) using the least amount of donors - make a flowchart
      1. What will be your limiting factors?
      2. What will be factors to consider when creating the flowchart
      3. Should be able to apply your chart and get the same answer
      4. Find your “flow”, create a chart
   5. Student work time (20 minutes)
   6. Evaluate - Switch plans with another group, do they come up with the same answer? (15 minutes)
      1. After test, have groups do a Q&A with each other
      2. What worked? What didn’t? What was difficult about the plan?
   7. Look at EDP - now we refine
      1. How can you make it better?
      2. How many iPhones are there? Why are there so many?
      3. Time to refine plan (10 minutes)
   8. Evaluate - Switch plans with another group, do they come up with the same answer? (15 minutes)
      1. After test, have groups do a Q&A with each other
      2. What worked? What didn’t? What was difficult about the plan?
3. **Exit Slip:** In your notebook, write one sentence about what you did today. Write one sentence explaining why it was important (relate this back to your essential questions!). Write one sentence about where you could use what you did today again. Write one sentence about how well you worked today in class. Write one sentence about what you think the next step should be.

Day 2:

1. **Enter Slip:** Imagine you are invited to a news program to discuss your flowchart. In one paragraph, explain to the audience watching the news why the project you worked on yesterday is important.
2. Note: If needed, students can do one more iteration of their flowcharts
3. Presenting your findings
   1. Your group will be creating a brochure to promote the product you have created.
   2. What are good concepts to include in your brochure? (Clear, easy to read, graphics, good colors, not too busy…)
   3. Brochure is submitted electronically to Ms. Lafin at the end of class. (put timer on board)
   4. Brochure is shared on google docs, each group member must be working on one part of it.
   5. DO NOT PUT NAMES ON YOUR BROCHURE - only team name.
4. If time permits, have students do a brochure gallery walk
   1. Students set up brochures around the room
   2. Do a pro/con walk - write down 2 thoughts about each brochure
   3. Share out with class (good to remind them of these thoughts for future projects)
5. **Exit Slip:**Take 5 minutes to reflect in your notebook on what we learned in this unit. Make a t-chart. On one side, write ideas we discussed today that you are very comfortable with. On the other side, write questions you still have or something you don’t understand. Your t-chart should not look like anyone else’s t-chart!

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Periodic check-ins with groups during challenge

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Unit test at the completion of this unit and the subsequent unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

Two different brochures – lower-level groups may use the full-page brochure instead of the tri-fold

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |