

**Life Science – General Biology**

**High School Biofabrication Storyline**

**Draft4**

** Kidneys...Need ‘em or Not?**

**Introduction**

This storyline was at one point much larger with activities related to STEM cells. Feedback from high school teachers suggested that it should be focused with a project-based lesson that is more easily incorporated into existing 1st-year Biology courses. There were several additional considerations that we share below:

* Multiple sections of biology courses have an agreed upon curriculum and a shorter, project-based approach provides the opportunity for one or more teachers to try it out within an already full course syllabus.
* Keep the focus on the organ loss phenomenon, as General Biology courses are generally taken during sophomore year (Grade 10) which is when students are becoming drivers and considering organ donation.
* HS-LS1 encourages a focus on interacting systems with multicellular organisms and that the kidney as one integral component would be something all students would find personally relevant, but not fully understood.
* English/Language Arts standards in many schools expect students to build persuasive writing skills in this grade area. The argument-driven challenge will encourage students to focus on strong evidence and convincing communications for a particular audience.
* Data Science skills are needed in most science courses to make decisions. Proficiency in the analysis of quantitative data is a skill in demand by almost all career pathways, including those in the life sciences. Students are encouraged to use quantitative data in their arguments.
* [Why should students investigate contemporary science topics—and not just "settled" science?](https://stemteachingtools.org/brief/2)

The current storyline is presented as an adaptable one-week or three-week unit depending upon student agency with project-based research, small group dynamics, and whether the unit is accomplished as is or within a larger curriculum unit focused on homeostasis and human body systems. A deeper dive into human body systems, genetics, and the pluripotency of stem cells might also deepen this unit for use in more advanced courses like anatomy and physiology.

**Disciplinary Core Ideas**

### [LS1.A: Structure and Function](http://www.nap.edu/openbook.php?record_id=13165&page=143)

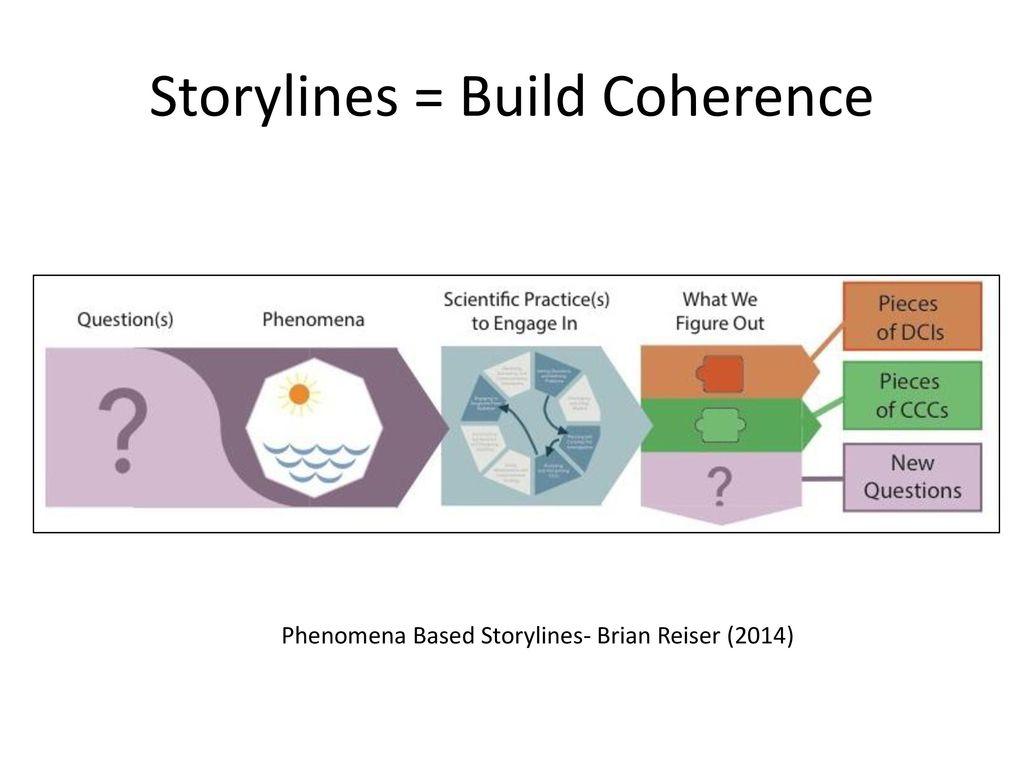
* [Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)](http://www.nap.edu/openbook.php?record_id=13165&page=143)
* [Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)](http://www.nap.edu/openbook.php?record_id=13165&page=143)
* [Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)](http://www.nap.edu/openbook.php?record_id=13165&page=143)

**Science & Engineering Practices**

* [Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.](http://www.nap.edu/openbook.php?record_id=13165&page=54)
* [Ask questions that arise from examining models or a theory to clarify relationships.](http://www.nap.edu/openbook.php?record_id=13165&page=54)

### [Analyzing and Interpreting Data](http://www.nap.edu/openbook.php?record_id=13165&page=61)

* [Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.](http://www.nap.edu/openbook.php?record_id=13165&page=61)
* [Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.](http://www.nap.edu/openbook.php?record_id=13165&page=71)
* [Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)](http://www.nap.edu/openbook.php?record_id=13165&page=71)
* Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations
* Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
* Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. ∙ Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
* Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
* Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

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| **Questions** | **Phenomena** | **Science & Engineering Practices** | **Activity** | **Learning Targets/ Figuring out** |
| Lesson | Scaffolding | Practices | Activity |  |
| How can people live with organ loss?  Why are kidneys important? What do they do? | Create a diagram of how you think the kidney works in the body.  Choice Videos as Anchoring Phenomenon/Phenomena  Selena Gomez Kidney Story – video  <https://www.youtube.com/watch?v=3HaqZjj0qvY>  Diary of a Dialysis Kid-video  <https://www.youtube.com/watch?v=yfNKyPTc_6E> Following years of dialysis, Chantal has her first kidney transplant at age 13 <https://www.youtube.com/watch?v=gv6oxyv1-WM> | Developing & Using Models  Asking Questions & Defining Problems | Individual, then small group modeling how the kidney works in the body and why it is so critical to life. Look for students' use of “homeostasis” and any systems-related ideas as they confer about their knowledge of kidneys. Make note of student conversations to help spur additional questions or wonderings for the [Driving Question Board](https://www.openscied.org/driving-question-board/#:~:text=The%20Driving%20Question%20Board%20(DQB,anchoring%20phenomenon%20and%20related%20phenomena.) (OpenSciEd).  Students post questions & wonderings to the Driving Question Board (DQB).  Facilitators may prompt for question areas such as: Kidney Disease, Kidneys’ function, Populations (ages) and % Affected, Relationship to Diet, etc. | Formative Assessment to elicit what students might already know or wonder about  Organ needs to maintain life with Interacting systems  Need for Matching Donors  Quality of life & mortality |
| 2. How do the kidneys help to maintain life? | Osmosis and Inquiry-based Kidney Simulation  <https://www.carolina.com/teacher-resources/Interactive/developing-and-analyzing-urine-samples-as-a-model-of-kidney-function/tr41615.tr>  Alt: Videos Illustrating Similar Osmosis & Diffusion using Dialysis Tubing <https://www.youtube.com/watch?v=Ji1wetFngLo>  <https://www.youtube.com/watch?v=Xxp6oponwkg>  Lecture/Demonstration/Simulation of Kidney Function <https://www.biointeractive.org/classroom-resources/kidney-function>  **Assessment:** Students respond to the question “Why is a urine sample important when having an annual physical with your doctor? | Asking Questions & Defining Problems  Developing & Using Models  Revising/Improving Models | Small groups improve their personal models with a small group consensus model of how the kidney works in the body and why it is so critical in maintaining life.  Using whole-class discussion, build a consensus model of how kidneys work. Then use the Summary Board to begin a class account of what we have figured out so far and what questions remain.  As students deliberate refining their models and using the term homeostasis, they usually expand their curiosity to consider other organs that are necessary for life. Be sure to add these questions to the DQB.  *\*Deepened understanding of organ functioning can be achieved without the memorization of the kidneys’ internal parts. However, understanding that there is an underlying structure is important to consider in regenerative medicine and how the body might repair a damaged kidney or how a kidney could be manufactured.* | * [Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)](http://www.nap.edu/openbook.php?record_id=13165&page=143) * [Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)](http://www.nap.edu/openbook.php?record_id=13165&page=143) * Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range   The assessment is used to learn if students can connect their learning to another relevant situation. |
| 3. What are the issues surrounding organ transplants? | Depending upon your own students’ Driving Questions you might adjust the student question. In this section, students are asked to research different aspects about organ loss.  Waitlists & Transplants  <https://www.kidney.org/atoz/content/transplant-waitlist>  <https://www.kidney.org/atoz/content/Antibodies-and-Transplantation>  Concerns with anti-rejection drugs.  <https://www.kidney.org/atoz/content/immuno>  <https://transplantliving.org/after-the-transplant/preventing-rejection/side-effects/> **Abstract:** Effect of immunosuppressive agents on long-term survival of renal transplant recipients: focus on the cardiovascular risk. [Boots JM](https://www.ncbi.nlm.nih.gov/pubmed/?term=Boots%20JM%5BAuthor%5D&cauthor=true&cauthor_uid=15341497)1, [Christiaans MH](https://www.ncbi.nlm.nih.gov/pubmed/?term=Christiaans%20MH%5BAuthor%5D&cauthor=true&cauthor_uid=15341497), [van Hooff JP](https://www.ncbi.nlm.nih.gov/pubmed/?term=van%20Hooff%20JP%5BAuthor%5D&cauthor=true&cauthor_uid=15341497). (2004)  <https://www.ncbi.nlm.nih.gov/pubmed/15341497> | Asking Questions & Defining Problems  Analyzing & Interpreting Data | Student teams consider the issues of kidney disease and would it be better to have a kidney transplant instead of going through dialysis all the time.  The readings could be accomplished using a 4-part jigsaw strategy to assist time available and reading or language issues.  Students should decide on the main take-aways from the narratives, not the details.  DQB questions may be addressed on these sites AND additional questions or wonderings may arise to be added to the DQB. Typically these have included ethics, time, transportation, and viable matchings for donated organs, and which organs are needed most. The BioFab Scientist Profile on [**Defining Problems**](https://www.youtube.com/watch?v=b656FEBx_Pk&t=5s) focuses on storage and transportation to preserve both donated and manufactured organs.  Add new understanding to the “What we figured out” Summary Board. | Graphical user interface  Description automatically generated with medium confidence |
| 4. Are there alternatives to consider beyond human-to-human organ donation? | Assign students the HHMI Biointeractive Lesson on Tissue Regeneration in Animals, which provides an easily understandable segue to regenerative medicine and what is or could be possible for humans. (50 mins) <https://media.hhmi.org/biointeractive/click/Regeneration/01.html>  This National Geographic documentary, [How to Build a Beating Heart](https://topdocumentaryfilms.com/build-beating-heart/) is a short intro but fascinating introduction to the work being done. (3:28 min)  [**Pig Kidneys Transplanted to Human in Milestone Experiment**](https://www.scientificamerican.com/article/pig-kidneys-transplanted-to-human-in-milestone-experiment/#:~:text=In%20late%20September%202021%20a,to%20fully%20simulate%20clinical%20transplantation.) Experts predict that such nonhuman-to-human “xenotransplants” may become a viable option within the next decade  Use the [**Communications**](https://www.youtube.com/watch?v=GX-k6p8C7sE&t=107s) talk to offer students a glimpse into one engineer’s journey into the manufacturing field. And the [**Using Evidence in Making Decisions**](https://www.youtube.com/watch?v=kxjVECemjNY&t=6s) video to get an inside look into growing cells to defeat the disease.  What is Regenerative Medicine? <https://www.youtube.com/watch?v=Mu9YkBY3IQY>  focus 8:30 – 25:00 (56:50) 2019 | Asking Questions & Defining Problems  Using data to find solutions  Obtaining, evaluating, and communi- cating information | This HHMI Lesson could be assigned as homework or used synchronously within a class period. Use this to further expand student thinking about organs and cellular systems' potential for humankind. Have students add their questions and wonderings to the DQB.  These are fairly long 15+ minute videos…could be used as a homework assignment for teams to consider further research on newest developments. They are about a decade apart but together help tell the story of how research has grown in this area.  Again Jigsaw with student groups so they are synthesizing and communicating pertinent info with their classmates. |  |

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| 5. If we had $100 million, which area of regenerative medicine should we invest in and why? | U.S. dept of Health & Human Services - [Organ Procurement and Transplantation Network](https://optn.transplant.hrsa.gov/) <https://optn.transplant.hrsa.gov/data/>  Student teams choose a major organ to research and make a pitch to the class for why their “organ” should be at the center of research and development.  Student teams prepare arguments and use their accumulated background knowledge of organ growth/repair/need to develop an argument and make a case for the monies to be directed to their area of concern.   * Kidney * Heart * Lung * Eyes * Limbs * Brain   A student group may want to take a more proactive tact and focus on healthy living to ward off diseases and organ loss.  *This is particularly interesting in this time of COVID-19 where they are predicting a greater need for dialysis due to more severe cases*. | Argument from Evidence  Explanation  Data Analysis & Computation  Communication  This is an engineering challenge…optimizing for benefit, cost & risk.  It also begs an ethics question about who benefits 1st? Children, the elderly, those who can pay??? | Student teams debate most viable options for research investment in manufacturing organs.  Given or student choice of additional organs to research & consider: heart, liver, lungs, eyes, limbs, pancreas, brain, etc. Students can work in small groups to build an argument for their chosen organ.  How to research and find credible sources?  Present their arguments/ideas to class for class decision.  Presentations can be directed to include:  **Mathematical Reasoning:** ...ie supply & demand, numbers needing the particular organ, availability of donors, etc.  **Ethical:** WHO BENEFITS? Quality of life effects?  **Feasibility:** Extent and progress to date of the research, viability of alternatives. | Students learn about multiple organs, areas of research & prepare arguments considering the socio-ethical-economic decisions to make.  SEP:  “Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. ∙ Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. ∙ Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. ∙ Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. ∙ Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).” |

These parts below were pulled to again put the focus on organ loss, systems for maintaining life, and the possibilities of contemporary research. We include them here because the links may be used to enhance this unit along the lines of cellular therapies.

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| What do STEM Cells have to do with organ growth? | Depending on student Personalized Cellular Therapies –  <https://learn.genetics.utah.edu/content/stemcells/scintro/> video-different types of stem cells from conception to adult  \*Optional depending upon how this best integrates with your curriculum. Teachers suggested this direction was more suited for Anatomy & Physiology or an advanced biology course. |  |  | * [In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a **single cell** (fertilized egg) that divides successively to produce **many cells**, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells.](http://www.nap.edu/openbook.php?record_id=13165&page=145) * [Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)](http://www.nap.edu/openbook.php?record_id=13165&page=145) |
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| How are scientists able to develop organs from personal cells? | Utrecht researchers develop mini kidneys from urine cells.  <https://www.hubrecht.eu/utrecht-researchers-develop-mini-kidneys-from-urine-cells/>  [Growing Organs](https://www.youtube.com/watch?v=jSWwDCNNtrE&t=2s) (6:38) 2021 [How We Are Growing Organs In The Lab? | Dr. Jim Wells](https://www.youtube.com/watch?v=ygXescPlj-M) TEDx (9:14 mins) 2018 | Asking Questions & Defining Problems | Article can be used to further develop awareness of cutting edge discoveries & possibly add to Driving Question Board (DQB) | STEM cells play a role  Need for more research  Need for Collaboration |