

<p>Grade: 11-12</p>	<p>Subject: Health Science 20, Biology 30</p>	<p>Units: Human Body, Diagnostics and Treatment, Genetics</p>
<p>Rationale: Students will analyze a hypothetical case, with real and emerging diagnostic applications, to develop an understanding of the role of diagnostics in healthcare.</p>		
<p>Background Information: Researchers in the Phenix Research Lab at the University of Saskatchewan (U of S) are developing innovative methods of diagnosing various diseases related to metabolic processes by detection with PET (Positron Emission Tomography). Some current and ongoing research and applications are in the area of screening in diseases such as Parkinson’s Disease (for example, to ensure effective drug interaction) and cancer (for example, predicting the probability of tumor metastasis).</p> <p>The research that goes on at the University of Saskatchewan is not only interesting, but has many important applications in the healthcare field. An example of this research is a project headed by Dr. Chris Phenix in the Department of Chemistry at the U of S. The project seeks to develop a non-invasive diagnostic method that uses biomarkers to detect Parkinson’s disease (see http://www.parkinson.ca/research/current-research-projects/). Additionally, this method also allows researchers to analyze drug efficacy and select candidates for drug trials. Currently, the only way to diagnose Parkinson’s Disease with 100% certainty is post-mortem brain analysis to find the presence of Lewy bodies.</p> <p>Notably, his work, and many others’ work, would not be possible without the world-class Saskatchewan Centre for Cyclotron Sciences (SCCS) research institute managed by the Fedoruk Centre, located on the University of Saskatchewan campus. It was completed in November 2014, and now the supply of radioisotopes for the Royal University Hospital (CBC News) is only minutes away. If you are looking for more information or an extension activity/field trip, the Centre offers school group tours; contact the Centre for more information.</p> <p>By creating substrates that mimic metabolites in the body, enzyme function can be better understood (enzymes are specialized proteins that speed up biochemical reactions); this is the premise of PET scanning. PET scans, unlike CT (Computerized Tomography) and MRI (Magnetic Resonance Imaging), detect changes in the rate of metabolism in cells and tissues. Tumors will typically have higher than normal glucose metabolism (will appear brighter on a PET scan) and neurodegenerative diseases, such as Parkinson’s, will show lower than normal glucose metabolism (PET scans will show areas of reduced brightness).</p>		

PET scans use substrates (sometimes a modified carbohydrate – see [Basics of FDG-fluorodeoxyglucose](#)) that match the metabolite in question, and have a radioactive tracer atom attached. Once the substrate is injected into the body, it enters cells and tissues where it is modified by enzymes. Once the enzyme has altered the substrate, it will remain in the cell and produce a radioactive signal that can be detected for PET imaging. The enzyme function gives a direct indication of changes in the rate of metabolism in the cell/tissue.

A basic understanding of enzyme function and the use of glucose as a cellular energy source will be necessary as students complete Part 3 and 4 of the case study.

Other diagnostics will be explored in this case study (blood tests, genetic screening, MRI, etc.) but the main focus will be on PET scans.

Curriculum Connections:

- HS20-HB2c: Research the symptoms, possible causes, stages and scope (e.g., cells, tissues, organs and/or systems) of a pathology that affects one or more body systems.
- HS20-DT1e: Research the operation, risks, benefits and imaging modalities (e.g., sound, light, radiation and nuclear medicine) of medical imaging tools, including X-ray radiography, magnetic resonance imaging [MRI], computed tomography [CT], ultrasound and positron emission tomography [PET]).
- HS20-DT1f: Describe technological advances in medical imaging tools (e.g., X-ray, ultrasound, computerized tomography and magnetic resonance imaging).
- BI30-GB1d: Discuss the importance of probability in predicting the likelihood of inheriting particular traits.

Lesson Objectives/Concepts:

- Students will analyze data to guide their inquiry.
- Students will complete relevant research in the areas of diseases, disorders, and diagnostics.
- Students will investigate PET scans: mechanism of action, image production, and diagnostic value.
- Students will look at patterns of inheritance of a genetic disorder.
- Students will summarize their findings in a succinct report.

Materials: Internet access for research, student handouts

Time: Approx. 2-45 min periods.

Introduction (5 minutes):

1. Very little direction or background information should be given before this activity, as it has been structured to promote group problem-solving, with the teacher as a facilitator.
2. You can explain that this case study has 4 parts, each part given one at a time, with

the end goal of a follow-up report that will be done individually (2 paragraphs).

3. Students are encouraged to collaborate and discuss questions together as a group to help with their report later.
4. At this time, the rubric could be distributed so students understand how they will be assessed at the end.

Activities/Procedure (about 75 minutes): *if you are short for time, Parts 1 and 4 could easily be assigned for homework, based on where you are at in the study*****

1. Hand out Part 1 of the case study. You can read it as a class, or have groups read it aloud together. They should consider the symptoms and collaborate as a group to narrow the disease down to four possibilities. [see teacher resource for guidance]
2. After about 15 minutes, you can come together as a class group and discuss any findings, leads, etc. for about 5 minutes.
3. Deliver Part 2 to each group. In this part, they will have to request information from you, the facilitator. They must request information from 5 different diagnostic tests and state the reason why. You will give them the requested information [see teacher resource] and if the diagnostic test result isn't there, just state 'inconclusive'. This part should take about 10 minutes.
4. Gather back as a large group and discuss their findings. They should realize that there is a genetic link and also that the nervous system (brain) is affected somehow. ~3 minutes.
5. Deliver Part 3 to each group. This part is where students will be doing a more thorough investigation of the two diseases (Parkinson's and Huntington's). The questions will guide them. Note that enzyme action will be discussed here, so they will have to have a basic understanding of this concept. This part may take about 20 minutes.
6. Discuss your findings as a group for about 3 minutes.
7. Distribute Part 4. In this part, the students will investigate treatment options. The questions will guide them. ~10 minutes.
8. Discuss as a group for about 3 minutes.

Summary: Wrap up the group discussion and lead students into the assessment part, noting the criteria in the rubric.

Assessment (about 10-15 minutes): see rubric for assessment of follow-up report. The rubric can be used as a self-assessment, peer-assessment, teacher-assessment or any combination.

Extensions/Connections:

For students who are curious about some of the careers related to PET scans, there is a webquest activity on the Glyconet website- [Canadian Glycomics high school resources](#).

Students could pursue further exploration into the half-lives of radioactive isotopes and other radiotracers that are used in diagnostics and treatment (in relation to Physics 30 or as a possible Student-Directed Study topic for any of the 20 or 30 level courses).

Another possibility would be to explore an example similar to the Parkinson's Disease diagnostic idea, but with Alzheimer's Disease. This article explains how a significant number of patients were formally diagnosed with Alzheimer's Disease (AD) but didn't have it. They were given AD drugs which have significant side effects, but were useless and also costly.

Article link: https://www.washingtonpost.com/national/health-science/brain-scans-show-many-alzheimers-patients-may-not-actually-have-the-disease/2017/07/18/52013620-6bf2-11e7-9c15-177740635e83_story.html?utm_term=.58c311f2c33f

THE FAMILY REUNION MYSTERY: A CASE STUDY IN SYMPTOM ANALYSIS AND DIAGNOSTICS

Part 1- The Symptoms

Imagine that you work as part of a medical investigative team that analyzes special cases. Your role is to look at the information presented to you, collaborate as a team, perform any tests you see fit, look at possible treatment options, and then report back to the family. They are paying you very well, so you need to have your facts and evidence straight in order to make the proper recommendations.

Family X had a reunion as they haven't seen each other for about 20 years. There were about 80 members who showed up and took part in the activities. Throughout the 3-day gathering, a couple of the family members discussed some recurring complaints from family members (roughly between the ages of 35-55) and then took note of some other signs as well.

They are worried about their family members, and also want to know how this could affect the younger generations, so they hire your team to investigate. Are these symptoms normal? Should they be worried and seek medical attention? Is this genetic? What can be done for these people? They want a thorough, but brief report of your findings.

Here are the signs and symptoms that they have noticed in 8 of their family members:

- Stoped posture
- Irregular blinking
- Stiff neck with soreness
- Some showed smaller than normal writing
- Some showed unusual slowness in finding their words
- Some showed hand tremors even when at rest

Questions/Tasks

1. By looking at the signs and symptoms, which body systems do you think are most affected? In your group, try to narrow it down to one main system.
2. Do some research. Use a website to see if these symptoms are related (try WebMD or a similar site). Are you able to come up with any possibilities?
3. Considering your answers for 1 and 2, try to narrow down to 4 possibilities of disease/disorders. Create a chart to summarize: common symptoms, how to diagnose, and possible treatment.

Part 3 - In-depth investigating - Parkinson's Disease and Huntington's Disease

Now that you have narrowed it down to two health issues, it is time to investigate them further to ensure you've diagnosed properly and can explain your findings better to the family. You will need to explain the different steps of the tests to the family so that they know it is safe.

Once Parkinson's Disease has progressed it can be diagnosed without scans, based on medical history, review of signs and symptoms, and neurological and physical examination. However, if the disease is in its early stages and these symptoms aren't present, molecular imaging scans to see brain functioning can be used. These imaging techniques can also be used if the patient is not responding to drugs.

Using the resource link given, and any other source of information, answer the following regarding how PET scans work. [Fact Sheet: Molecular Imaging and Parkinson's Disease](#)

Questions/Tasks

1. How do PET scans (molecular imaging) have an advantage over other tests such as X-ray, CT, and ultrasound?
2. Now, the Royal University Hospital gets its radioisotopes for PET scans from right in Saskatoon. Look at the following article - [Global News- Saskatchewan cyclotron to help patients get a PET-CT scan sooner](#), and answer these questions:
 - a. Where do they get the radioisotopes from now?
 - b. Where did they used to get them from?
 - c. Name 3 problems that have been alleviated by getting their supply in Saskatoon.

To understand how PET scans work, it is important to review metabolism in the body. Questions 3 and 4 relate to cellular respiration.

3. What is the body's main energy source? What energy source does the brain and a body in a fasting situation use? Explain how that molecule gets into the cells.
4. What is an enzyme's purpose in the body? How does an enzyme alter glucose once it is in the cell?
5. In terms of molecular imaging, what is a probe? What is a radiotracer?
6. If an area of the body had high rates of metabolism, such as a tumor, what would the PET image look like?
7. If an area of the brain had low rates metabolism (processes have slowed down) such as with Parkinson's Disease, what would the PET image look like?
8. A common radiotracer used in PET is ^{18}F -fluorodeoxyglucose- (FDG) (see below) which incorporates the fluorine-18 radioisotope that has a half life of 110 minutes. Considering its structure and half-life, state two reasons why this molecule is used in PET scanning.

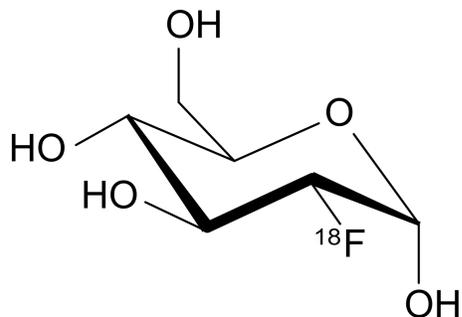


Image: Wikipedia Commons, https://upload.wikimedia.org/wikipedia/commons/thumb/5/5d/Fluorodeoxyglucose_18-F_skeletal.svg/217px-Fluorodeoxyglucose_18-F_skeletal.svg.png

9. Would you consider PET to be safe? Would you recommend the family members from the reunion to get the scans? Why or why not?

Huntington's Disease is a genetic disorder that is found on chromosome 4. Using the following links on [Huntington's Disease from Medline Plus](#) and [Diagnosing- Mayo Clinic Huntington's Disease Diagnosis](#), answer the following questions.

10. What does the term autosomal dominant mean?
11. What is the likelihood that someone with Huntington's disease will pass it on to their offspring?
12. Explain the risk of getting Huntington's at an earlier age as it is passed down through many generations.
13. Explain what a predictive genetic test is.
14. What are you doing to tell the family about Huntington's inheritance? What advice will you give them?

Part 4 - Treatment Options

There is no treatment that can alter the progression of Huntington's Disease, but there are some options to lessen the symptoms. Considering the treatment options in the resource from the [Mayo Clinic - Huntington's Disease Treatment](#), outline two recommendations you will give the family.

With Parkinson's Disease, treatments are available to minimize the symptoms and prolong the early stages of the disease, but there is no cure. Parkinson's disease is associated with low levels of dopamine, so the drugs administered are often to replace the dopamine. Sometimes these drugs are ineffective for patients, so further testing could be helpful in determining the probability of the efficacy of the medications.

Questions/Tasks

1. What is dopamine and what does it do?
2. List 2 medications that are currently being used to treat Parkinson's and what they do.

Getting medications approved is a very long process, and it requires evidence of high success rates to be considered for approval. Another application of PET scans is to use specific radiotracers to mimic the medication to determine if it will be effective for patients. After this screening, only those who responded will be chosen to test the medication, thus increasing the response to the medication and help ensure its approval.

3. How could this information help the future of Parkinson's Research?

Case Study Assessment

Using the following rubric, complete a two paragraph summary which you could present to the family. Ensure that you discuss:

1. How you will break the news to the family and how this information may affect the family's future decision making
2. How the signs and symptoms indicate the specific diseases
3. Which diagnostic tests were completed and their results
4. Possible treatment options.

Category	4	3	2	1
Accuracy	All supportive facts and information is reported accurately.	Almost all supportive facts and information is reported accurately.	Most supportive facts and information is reported accurately.	Most supportive facts and information were inaccurately reported.
Amount of Information	All topics (see above) are addressed thoroughly with about 2-3 sentences about each.	All topics (see above) are addressed with about 1-2 sentences about each.	Most topics (see above) are addressed with about 1-2 sentences about each.	Only some topics were addressed and there was very little support shown for the topics.
Quality of Information	Information clearly related to the main topic. It includes several supporting details.	Information clearly related to the main topic. It provides 1-2 supporting details.	Information clearly related to the main topic. No details are given.	Information has little or nothing to do with the main topic.
Knowledge Gained	Student accurately addressed all topics with accurate facts and appropriate vocabulary and terminology was used.	Student accurately addressed most topics, while using appropriate vocabulary and terminology.	Student accurately addressed most topics, but used 1-2 terms incorrectly.	Student accurately addressed some topics and showed several inaccuracies in terminology.
Representation	Written and/or oral communication is well organized and effective	Most of the written and/or oral communication is well organized and effective.	Some of the written and/or oral communication is organized and effective.	Written and/or oral communication is lacking organization.

***NOTE: this rubric could be used for alternative products of learning, such as an interview or point-form notes ***