Case File: Measles in Black

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Abstract:

This action plan is designed to promote scientific literacy and open the door for conversation about responsible journalism and how scientific research is conveyed to the general public. This activity is designed to supplement an existing unit on infectious diseases and the immune system. During this activity, students will analyze data from a scientific journal about the mode of action of the measles virus in the human body and use the data to answer the question: "Does the measles virus infect epithelial cells, immune cells or both?" Once they have analyzed the data and drawn their own conclusions, they will analyze a news-style article citing the original paper to assess if the major points of the source article were conveyed appropriately and discuss the importance of responsible journalism in reporting scientific research.

Rationale:

In this activity, students will be able to further their knowledge about the measles virus as well as the different types of immune cells and the roles they play in coordinating the immune response and establishing immunological memory. As of June 20th, 2019, 1,077 individual cases of measles have been confirmed in 28 states so far this year- the highest number of cases in the United States since 1992, despite being declared eliminated in 2000.[1] One contributing explanation for this increase is a rise in vaccine hesitancy and a general mistrust of science. However, the main objective of this lesson is to start a conversation about how science is presented to the general public and how news outlets may generalize or otherwise skew scientific research into forms that are digestible to the general population while also being driven by their own metrics of revenue or generating traffic to their websites. While not always the case, this idea that something that is published may not necessarily be the most accurate representation of scientific literacy and a healthy suspicion of sensationalist journalism, this activity encourages students to do their own research and draw their own conclusions.

Description of teaching unit:

This unit is designed to take between 70 and 160 instructional minutes, depending on the needs of students. This can be reduced by assigning reading and analysis assignments as homework if necessary.

- Cambridge CIE 9700 Syllabus (AS Biology) Objectives:
 - 10.1.b: State the name and type of causative agent of measles (limited to *Morbillivurus*)
 - 10.1.c: Explain the transmission cycle of measles
 - o 11.1.b: Explain the role of macrophages and lymphocytes on immune response

• Learning Outcomes- Students will be able to:

- Use active reading techniques to read and understand a scientific journal article
- Analyze complex data to draw conclusions
- Compare the article to a secondary news-style article and discuss differences between the two publications
- Analyze the legitimacy of a news article from a seemingly reliable source and discuss what makes "bad science" bad
- These objectives and outcomes will be achieved through the following activities:
 - **Introduction:** 10-15 minutes; students will receive background information (relevant vocabulary and background of the measles virus, the immune system and the respiratory tract)
 - Assignment 1: Analysis of Prodromal and Early Cases*: Approximately 30 minutes (depending on reading level and student ability); students will use the data provided to answer the questions and draw conclusions about the data from these cases
 - Assignment 2: Analysis of Established and Late Cases*: Approximately 30 minutes (depending on reading level and student ability); students will use the data provided to answer the questions and draw conclusions about the data from these cases
 - **Small Group Discussion:** Approximately 20 minutes; Students will meet in small groups to compare their analysis of the cases provided and start to draw conclusions about the cells and tissues that were affected by the virus
 - Whole Class Discussion: Approximately 20 minutes; discuss the conclusions that the groups reached and the impact of the data as a whole.
 - News Article Reading and Questions*: Approximately 20 minutes; Students will read the second article and answer the questions provided.
 - **Spotting Bad Science*: Approximately 20 minutes;** Once students have read the second article, have them read the "Spotting Bad Science" infographic and look for these features in the article.
 - **Final Discussion: Approximately 20 minutes;** Was the article "bad science"? If so, how could the author have fixed it? Is it possible that news sources can be irresponsible when reporting on scientific publications? What can be done to combat this?

Note: Any activity marked with an asterisk can be assigned as homework if there are time constraints for in-class reading.

Materials- Each student should have:

- Pens/pencils
- Printed copies of:
 - Student Pages- data and assignment questions
 - Copy of Article #2: "Measles erases the immune system's memory" by Laura Sanders (sciencenews.org)

• Access to a digital or printed copy of the "Spotting Bad Science" graphic from Compound Chem (https://www.compoundchem.com/2014/04/02/a-rough-guide-to-spotting-bad-science/)

Data Collection/Student Assessments- Student learning will be assessed in the following ways:

- Unit assessments for infectious diseases and immunity (these assessments incorporate other topics, but will include questions on this activity)
- Written analysis of data assignments can be collected and graded
- Discussion questions can be collected and graded or used as a verbal formative assessment tool
- Article 2 questions and "bad science" chart can be collected and graded
- Participation during class discussions

CATALySES summer institute elements specifically included (UF connections):

- So, What is an Emerging Pathogen? (June 16th- Dr. Morris): Emphasis on distrust of science being a major driver for emerging and re-emerging pathogens (vaccine hesitancy)
- Antimicrobial Stewardship (June 17th- Dr. Venugopalan): Idea that what you tend to hear (even from medical professionals) may not necessary align with best practices; variation of knowledge even within a field
- Genetic Engineering in Crops (June 24th- Dr. Barbey): Continued to emphasize distrust of science based on misconceptions that may be furthered by news media

References Cited:

1. Measles | Cases and Outbreaks | CDC. (n.d.). Retrieved from https://www.cdc.gov/measles/cases-outbreaks.html (accessed June 25th, 2019; data is updated every Monday)

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CATALySES 2019 Action Proposal- Lesson Plan

Case File: Measles in Black?

Key Questions:

- What role(s) do different white blood cells play in the immune system?
- What cells and tissues are primarily affected by the measles virus?
- Does this study provide valid results to support the conclusions stated?
- To what extent (if any) did the news site sensationalize or generalize the information presented in the original source article?

Science Subject: Biology, Anatomy and Physiology (Immune System, Respiratory System)

Grade and Ability Level: High School- Cambridge CIE Biology, AP or advanced honors classes. Could be further modified for lower grades or regular level classes.

Overall Time Estimate: Approximately 170 minutes if done entirely in class; can be reduced to approximately 65 minutes if all reading is done as homework

Learning Styles: primarily verbal with some visual, logical and social elements

Lesson Summary: This activity is rooted in the idea of scientific literacy. Students are asked to decipher a technically complicated scientific journal entry and write their own abstract, challenging them to not only read the technical paper but also figure out exactly what the article is trying to say and if there is a solid conclusion that can be drawn. They will then assess an online news article referencing the same journal entry and discuss what elements were changed between the two publications and the implication of those changes.

Student Learning Objectives with Standards: Standards according to the Cambridge CIE 9700 syllabus

- State that measles is caused by *Morbillivirus* and is easily transmitted between humans (10.1.b, 10.1.c)
- Explain the role of macrophages and lymphocytes on the immune response (11.1.b)

Materials: Each student will need a printed copy of each of the articles with the abstract of the journal article removed; highlighters may be provided to help with annotating if needed.

Background Information: This activity requires very little background knowledge. A basic understanding of the measles virus and the cells of the immune system (lymphocytes, macrophages, dendritic cells), but no in-depth background knowledge is required. Students will receive background information defining important terms and outlining the main components of a research paper.

Advance Preparation: None other than providing printed reading materials.



Procedure and Discussion Questions (with time estimates)

- Introduction/background: 10-15 minutes
 - Hand out introduction sheets, go over background vocab and any additional information needed (white blood cells, vocab, overview of the measles virus and organs associated with the immune system)
- Assignment #1 (Analysis of Prodromal and Early Cases): 30-50 minutes, depending on students*
 - Hand out patient files info sheet for prodromal and early cases and have students analyze and categorize the data on the included assignment sheet
 - * As long as students have the background knowledge to interpret the data, this can be assigned as homework.
- Assignment #2 (Analysis of Established and Late Cases): 30-50 minutes, depending on students*
 - Hand out patient files info sheet for established and late cases and have students analyze and categorize the data on the included assignment sheet
 - *This can also be assigned as homework. Alternatively, you can have students work in groups and have half of the group do assignment #1 and the other half assignment #2 and discuss their answers.
- Small Group Discussion: 20-30 minutes
 - Put students in groups of 3-4 and have them discuss the questions on assignment #3
 - Depending on time constraints, you can have one student write the responses or circulate the room as they discuss the questions.
- Whole Class discussion: 20-30 minutes
 - Discuss the article itself- was there anything that jumped out as interesting or odd about the research? (One thing could be the extremely small sample size- a sample size of 23 is extremely small)
 - Have students compare their results and conclusions with other groups.
- Read second article and answer questions: 20-25 minutes (can be assigned as homework)
- Spotting Bad Science Poster Analysis: 20-30 minutes*
 - After reading the second article, give students access to the "Spotting Bad Science" Poster by Compound Chem- this can be projected, printed or accessed digitally. Have them read the infographic and assess the features of "bad science" that may be present in the news-style article.
 - *Can be assigned as homework
- Final Discussion: 20-30 minutes
 - Could this idea be applied to other topics?
 - Is it possible that news sources can be irresponsible when reporting on scientific publications? What can be done to combat this?

Assessment Questions: Can be incorporated into existing content questions about the nature of the measles virus and the immune system. Learning can be best assessed by reading and grading student submitted abstracts and observing class discussion.

Extensions: After this activity, students could also be asked to find their own articles and assess their validity based on source texts. This activity could also be extended to relate to many other topics.

Resources/References:

- Student Pages & Answer Key (PDF)
- Source Article: Allen, I. V., Mcquaid, S., Penalva, R., Ludlow, M., Duprex, W. P., & Rima, B. K. (2018). Macrophages and Dendritic Cells Are the Predominant Cells Infected in Measles in Humans. MSphere, 3(3). doi:10.1128/msphere.00570-17. Retrieved from https://msphere.asm.org/content/3/3/e00570-17/article-info
- Secondary Article: Sanders, L. (2019, June 03). Measles erases the immune system's memory. Retrieved from https://www.sciencenews.org/article/measles-immune-system-memory-infection
- Spotting Bad Science Infographic by Compound Chem- retrieved from: https://www.compoundchem.com/2014/04/02/a-rough-guide-to-spotting-bad-science/

Case File: Measles in Black?



The big question:

Does the measles virus infect epithelial cells, immune cells, or both?

Through this assignment, your job will be to analyze the results of a research paper and decide if the conclusions drawn are sufficient to answer this question.

Part 1: Debrief and Background White Blood Cells of the Immune System:

- **B Lymphocytes**: cells that originate in the bone marrow and have the ability to differentiate into plasma cells that will ultimately produce antibodies; they also produce memory cells that help your body remember pathogens that they have encountered in previous infections
- **T Lymphocytes:** cells that originate in the thymus that preform other immune responses such as killing infected cells, helping to coordinate B cells and other T cells or send signals to other immune cells; T cells also produce memory cells
- **Macrophages:** Cells that migrate into tissues to quickly ingest debris, infected cells and pathogens via phagocytosis
 - **Multinucleated Giant Cells (MGCs):** A special class of giant cell formed by the fusion of many macrophages in tissues
- **Dendritic Cells:** Important cells that have the ability to "present" foreign antigens to other immune cells to help in the organization of an immune response
- Platelets: Small cells found in the blood stream which are important in blood clotting

Other Important Vocabulary:

- **Epithelium:** class of cells that form the lining of various hollow organs, glands, skin, etc.
- **CD11c cells:** a type of transmembrane protein found on macrophages, some B lymphocytes and dendritic cells
- CD150: a glycoprotein found on the surface of T lymphocytes, B lymphocytes and dendritic cells
- **Inflammation:** can be triggered by an immune response- an increased amount of blood flow to a specific area can lead to pain, redness and swelling; certain white blood cells respond to inflammation by accumulating in that area
- Dissemination: widely dispersed in a tissue, organ, or the entire body
- **HIV:** Human Immunodeficiency Virus; this virus attacks a certain type of T lymphocyte that helps to fight infections, so HIV positive individuals often have compromised immune systems and are more prone to infections
- Lymphoma: Cancer of the lymphocytes (B cells and T cells); severely affects immune function
- Leukemia: Cancer that affects the bone marrow, where all blood cells (including the white blood cells of the immune system) are made
- **Carnification /Carnified lung tissue:** Tissue in which soft, flexible tissue of the lung is converted to fibrous tissue as a result of unresolved pneumonia

The Measles Virus (MV)

- Viral infection caused by the *Morbillivirus,* which is one of most infectious human virus
- Primarily transmitted by aerosols (spraying caused by coughing/ sneezing) from an infected host to the upper respiratory tract of susceptible individuals
- Vaccine is widely available, but is not really effective in preventing the spread of the infection in populations where less than 90% of individuals are vaccinated

The stages of a measles infection





Adenoids nus Tonsils Nasal Cavity Pharyna Oral Cavity Epiglottis Tonque Esophagus Larvnx Trachea **Right Bronchus Right Lung** Left Bronchus Ribs Pleura Pleural Space Bronchiole Diaphragm Alveolus (Air Sac) hum Mucus Intiliant Cilia **Pulmonary Vein** Cells Capillaries

The Respiratory System

Background

- Many immune cells can cause inflammation and tissue damage as they fight infections, and they tend to accumulate in these infected tissues, so we can look for the presence of these cells as an indication that infection was present in that area.
- Previous evidence suggested that the measles virus attacks CD150 receptors that are only found on immune and other types of blood cells, while other research presented evidence that it also can attack receptors found on epithelial and neuronal (nerve) cells.
- The data presented in this paper:
 - Analyzed samples from 23 natural measles cases in different stages of infection and studied the types of cells that were infected and the types of receptors present on these cells
 - This data collected from 21 autopsies and 2 biopsies spanning a total of 38 years from various geographic regions that has the presence of MV in at least one organ

Patient Summary: Clinical features, demographic information and outcomes

Phase of measles ^a	Case no.	Age (yrs)	Sex ^b	Country of presentation	Yr of presentation	Time from onset of rash to biopsy or to death	Coexisting disease	Disease outcome /cause of death
				•	•			
Prodromal	1	4	Μ	Northern Ireland	1970	No rash	Congenital heart disease	Congenital heart disease
	2 ^c	12	М	South Korea	2000	No rash	None	Alive/well
Early	3 ^c	10	F	South Korea	2000	<3 days	None	Alive/well
-	4	3	Μ	Northern Ireland	1962	3 days	None	Staphylococcal bronchopneumonia
	5 ^c	14	М	Brazil	1997	3 days	Treated lymphoma	Disseminated measles
Established	6	<1	F	Northern Ireland	1966	10 days	Congenital heart disease	Measles pneumonia/congenital heart disease
	7 ^c	3.5	F	Côte d'Ivoire	1991	<15 days	HIV-1 positive	Measles tracheitis/MV ⁺ mucus glands
	8 ^c	2.5	F	Côte d'Ivoire	1991	<15 days	HIV-1 negative	MV pneumonia/MV ⁺ in thymus
	9 ^c	1.5	Μ	Côte d'Ivoire	1991	<15 days	HIV-1 negative	MV pneumonia/MV ⁻ in thymus
	10 ^c	1.0	Μ	Côte d'Ivoire	1991	<15 days	HIV-1 negative	MV pneumonia
	11 ^c	<1	F	Côte d'Ivoire	1991	<15 days	HIV-1 negative	MV pneumonia
	12 ^c	<1	Μ	Côte d'Ivoire	1991	<15 days	HIV-1 positive	MV pneumonia
	13 ^c	1	F	Côte d'Ivoire	1991	<15 days	HIV-1 positive	MV pneumonia
	14 ^c	0.6	F	Côte d'Ivoire	1991	<15 days	HIV-1 positive	MV pneumonia
	15 ^c	0.6	F	Côte d'Ivoire	1991	<15 days	HIV-1 positive	MV pneumonia
	16 ^c	1.2	М	Côte d'Ivoire	1991	<15 days	HIV-1 positive	MV pneumonia
Late	17 ^c	4	м	Brazil	1997	20 days	Treated lymphoma	Disseminated measles
	18 ^c	<1	Μ	Northern Ireland	1968	42 days	Genetic immune disease	Disseminated measles (vaccine induced)
	19 ^c	5	Μ	United States	1965	42 days	Treated leukemia	Disseminated measles
	20 ^c	5	Μ	United States	1971	180 days	Treated leukemia	Disseminated measles
	21 ^c	6	Μ	United States	1971	180 days	Treated leukemia	Disseminated measles
	22 ^c	68	F	Switzerland	1971	No rash	Treated leukemia	Disseminated measles
	23 ^c	7	Μ	Northern Ireland	1989	49 days	Treated leukemia	Disseminated measles

^aDefinitions of phase of measles are based on the time interval between the time of the appearance of a rash and the time of biopsy or death. Prodromal, no rash; early, 1 to 3 days; established, 4 to 15 days; late, >15 days.

^bF, female; M, male.

^cCase published (23, 37, 61-63).

Part 2: Patient Files Assignment #1: Analysis of Prodromal and Early Cases (Cases 1-5)

Instructions: Use the attached information to analyze these cases and answer the following questions.

- 1. What is an antigen? Why is it important to test for antigens in the tissues and organs of these patients?
- 1. What does the term "prodromal" mean? ______
- 2. Out of these 5 patients, which one(s) passed away from measles? Why do you think this occurred at such an early stage of the disease?
- 3. What organ systems were assessed in most of these patients?

Summary: Summarize your findings with these patients in the chart below.

C a s e	Tissues/ Organs assessed	Where was MV found?	Where were immune cells found?	Other Notes/ Details
1				
2				
3				
4				
5				

Part 2: Patient Files Prodromal Cases (Cases 1 & 2)

• Prodromal cases are those that occur after initial symptoms but before the onset of full symptoms or fever

Patient #1

- MV antigens were not detected in the epithelium of the trachea, bronchi or alveoli. Architecture of the respiratory tract appeared normal.
- MV infection was confirmed in the lymph nodes, thymus and spleen
- MGCs were located in the spleen and were positive for MV

Patient #2

- Patient made a full recovery following an appendectomy
- No evidence of infection (MGCs or measles-induced lesions) of the epithelium
- MV antigen on white blood cells and MGCs in lymphoid tissue within the appendix
- B cells were identified in the epithelium as well as within the lymphoid tissue of the appendix

Early Cases (Cases 3-5) Patient #3

- Presented with acute inflammation of the appendix and made a full recovery
- Appendix showed numerous inflammatory cells in the epithelium and results suggested that macrophages accumulate in appendicular epithelium in close association with active sites of MV infection
- CD150 staining demonstrated immune cells in the epithelium, but were more numerous in the underlying lymphatic tissue within the appendix
- Lymphatic tissues in the appendix were most heavily infected; MV was observed to colocalize with CD11c cells in these tissues
- Staining showed evidence of severe disruption of normal architecture in the epithelium due to the infiltration of immune cells within this tissue

Patient #4

- Patient developed staphylococcal bronchopneumonia and despite treatment died 3 days after initial onset of measles symptoms
- MV antigen was present in the thymus but not in the spleen or alveolar or bronchiole epithelium

Patient #5

- Lung tissue showed significant inflammatory changes and the presence of numerous macrophages and MGCs
- MV antigen was present primarily in the pancreas

Part 2: Patient Files Assignment #2: Analysis of Established and Late Cases (6-23)

Instructions: Use the attached information to analyze these cases and answer the following questions.

- 1. What is the most common condition seen in these cases (related to measles)?
- 2. What type of tissue was the most damaged by these infections?

Stage	Tissues/ Organs assessed	Where was MV found?	Where were immune cells found?	Other Notes/ Details
Established - General				
Established - Patient #9				
Established - Patient #10				
Established - Patient #12				
Established - Patient #13				
Late- General				
Late- Patient #17				
Late- Patient #20				

Part 2: Patient Files

Established Cases (Cases 6-16)

NOTE: for these cases, the authors presented an overview of their findings rather than going through each patient one by one.

General Info (applied to all or most cases)

- In all cases except two where the infection was classified as established, there was a fatal outcome associated with measles pneumonia and all had marked MV infection in the alveoli
- The trachea showed occasional spots of inflammation with infiltration by lymphocytes and macrophages.
- MV antigens were undetectable in the tracheal epithelium in all cases except case #12
- In all of the infected foci found in bronchi, macrophages and CD150 cells were consistently found
- Bronchiole epithelial mucus glands frequently tested positive for MV and showed fragmentation and cell loss
- Necrotic (dead tissue) epithelium was found mixed with MV-infected cells, dendritic cells and macrophages in the bronchial spaces, although the lining epithelium appeared normal and not infected
- MV antigen-containing MGCs lined the alveoli

Specific Data:

- Patient #9: Pancreas was assessed and MV cells were found to NOT colocalize with immune cells
- **Patient #10:** Extensive damage to the alveoli was observed- alveoli contained many inflammatory cells and MV antigen either partially or totally covered the alveoli walls
- Patient #12: Single focus of infection found on the epithelial surface of the trachea
- **Patient #13:** Extensive damage to the alveoli was observed- alveoli contained many inflammatory cells and MV antigen either partially or totally covered the alveoli walls

Late Cases (Cases 17-23)

General Info (applied to all or most cases)

- Coexisting immune system diseases (lymphoma, leukemia or genetic immunodeficiency) were found in all late cases
- Disseminated measles involved several organs
- The majority of infected immune cells in the lungs were macrophages or dendritic cells

Specific Data:

- Patient #17: MGC present as MV+ in lungs
- Patient #20: MV positive cells were seen against a carnified background in the alveoli

Part 3: Drawing Conclusions Assignment #3: Analysis

Meet with your team and compare data from assignments 1 and 2. Discuss and answer the following questions as a group.

- 1. Does it appear that measles infects epithelial tissue?
- 2. What organs were most affected?
- 3. Does it appear that measles infects organs of the immune system?
- 4. Does it appear that measles infects immune cells?
- 5. How would your answers to questions 1-4 explain the spread of measles through the body?
- 6. If you were in charge of writing a "news-style" article summarizing the findings of the original paper, what would you title it?

Assignment #4: Discussion

During the whole class discussion, compare your answers to the other groups and take notes of what is discussed.

SO.... Does measles mainly infect epithelial cells, immune cells or both? What do you think?

Part 4: In the News What is a reliable source?

Not all sources of news are credible, and even science can be falsely interpreted or reported in an irresponsible way by "credible" sources.

A reliable source is one that provides a thorough, well-reason theory, argument or discussion based on strong evidence.

• Based on this definition, would the paper that we used be considered a reliable source? Why or why not?

The next thing you will read is an article from sciencenews.org. This article was published in May 2019 and contains citations.

• Take a minute to look through the article. Would you expect this to contain reliable information? Would you trust this publication and this article?

Assignment #5: Article #2 Reading

Read the article "Measles erases the immune system's memory" by Lauren Sanders and answer the following questions.

- 1. What is "immune amnesia"?
- 2. According to Rik de Swart, what ALWAYS reduced childhood mortality?
- 3. What protein is found on cells that are susceptible to measles?
- 4. What immune system cells produce memory cells?
- 5. How much more likely were children who had been infected with measles to need another prescription for an infection?
 - a) There are statistical analyses that can be done to determine if this is significant and if there is a correlation, but in your opinion does this seem like a significant value?
 - b) What are some other things that could impact this statistic?

Part 5: Final Discussion

With your group, discuss the second article- even though it cited reliable sources, do you feel that it accurately summarized the data you analyzed from the original paper? Use the following questions to guide the discussion:

- Was there enough data (figures, numbers, statistics) to support the overall claim of this article?
- How could this article be improved?

Summarize the discussion and what your group ultimately concluded below:

Next, look at the infographic about Spotting Bad Science. Even though this article DID cite reliable sources, can you identify any "red flags" in this article? Fill out the chart below.

Feature	Definition	In this article? (Yes/No)	Rationale- is it okay? How could they fix it?
Sensationalist Headlines			
Misinterpreted Results			
Conflicts of Interest			
Correlation & Causation			
Unsupported Conclusions			
Problems with Sample Size			
Unrepresentative Samples Used			
No Control Group Used			
Selective Reporting of Data			
Unreplicable Results			
Non-Peer Reviewed Material			

Measles in Black- Teacher Guide

Part 1: Debrief and Background

- Depending on the amount of background your students have on these topics, students may need some assistance going through the vocab terms and diagrams in this section.
- Topics discussed:

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- Cells of the Immune System
- Information about other diseases mentioned (lymphoma, HIV and leukemia)
- Overview of the measles virus and the viral cycle of measles
- Overview of the basic structures of the respiratory tract

Assignment #1: Analysis of Prodromal and Early Cases (Cases 1-5)

Instructions: Use the attached information to analyze these cases and answer the following questions.

- 1. What is an antigen? Why is it important to test for antigens in the tissues and organs of these patients?
 - A specific chemical marker (usually a protein or sugar) on the surface of cells that allows them to be identified; allows us to analyze what types of cells or viral particles are present in certain tissues or organs
- 2. What does the term "prodromal" mean? Before the onset of a full set of symptoms or fever
- 3. Out of these 5 patients, which one(s) passed away from measles? Why do you think this occurred at such an early stage of the disease?
 - **Patient 5: Disseminated measles;** this patient had been treated for lymphoma (cancer of the lymph nodes), so it is likely that the cancer affected the patient's immune system/ white blood cells and they were unable to fight the measles infection
- 4. What organ systems were assessed in most of these patients? Respiratory and immune/lymphatic organs

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	Tissues/ Organs assessed	Where was MV found?	Where were immune cells found?	Other Notes/Details
1	Trachea, bronchi, alveoli, lymph nodes, thymus, spleen	Lymph nodes, thymus and spleen	MV-positive MGCs in the spleen	-Respiratory tract appeared normal
2	Appendix	-White blood cells and MGCs in the lymphoid appendix tissue	-Epithelium AND lymphoid tissue in appendix	-Patient made full recovery after appendectomy -No infection found in the epithelium of the appendix
3	Appendix	-Lymphatic tissue most heavily infected (appendix) -Immune cells also infected	-Inflammatory cells in epithelium AND lymphoid tissue of the appendix -More in lymphoid tissue	-Inflammation of appendix -Immune cells in the epithelium caused severe disruption of normal architecture
4	Thymus, spleen, alveolar epithelium, bronchiole epithelium	Thymus	No data	-Developed pneumonia and died 3 days after measles onset
5	Lung tissue, pancreas	Primarily in the pancreas	-Macrophages and MGCs in the lung	-Significant inflammatory changes in the lung

Assignment #2: Analysis of Established and Late Cases (6-23)

Instructions: Use the attached information to analyze these cases and answer the following questions.

- 1. What is the most common condition seen in these cases (related to measles)? Measles pneumonia
- 2. What type of tissue was the most damaged by these infections? Lungs/specifically the alveoli

Stage	Tissues/ Organs assessed	Where was MV found?	Where were immune cells found?	Other Notes/ Details
Established- General	-Lungs/ alveoli -Trachea -Bronchi	-Alveoli -Epithelium of the bronchi mucus glands -Necrotic tissue in spaces of the bronchi	-Inflammatory cells in the trachea -Macrophages and CD150 cells in the bronchi -Infected MGCs in alveoli	-Fatal pneumonia -Fragmentation and cell loss in bronchi -Necrotic tissue in bronchiole spaces BUT the epithelium was normal
Established- Patient #9	-Pancreas	-Pancreas	-NOT in the pancreas	
Established- Patient #10	Alveoli/ Lungs	-Partially or fully covering alveolar walls	-Alveoli contained inflammatory cells	-Extensive damage to alveoli
Established- Patient #12	Trachea	Single focus on epithelium of trachea		
Established- Patient #13	Alveoli/ Lungs	-Partially or fully covering alveolar walls	-Alveoli contained inflammatory cells	-Extensive damage to alveoli
Late- General	Many	Many organs/ totally disseminated	-MV+ macrophages and dendritic cells (inflammatory!)	-Coexisting immune system diseases in all cases
Late- Patient #17	-Alveoli	-MV cells on carnified background of alveoli		
Late- Patient #20	-Lungs	-Lungs	-MV+ MGCs in lungs	

Assignment #3: Analysis

• Answers to these questions may vary. I recommend splitting the students into groups of 3-4 and grading them on the discussions that they are having and the thoughtfulness of their responses.

Assignment #4: Discussion

- Students can be graded on their participation during the group discussion or based on the notes taken during the discussion.
- Another option is to set this up as a Socratic seminar-style discussion where different students contribute different viewpoints.

Assignment #5: Article #2 Reading

This assignment can be done in class or assigned as homework.

1. What is "immune amnesia"?

2.

- "Measles silently wipes the immune system's memory of past infections", leaving people vulnerable to other viruses and bacterial infections
- According to Rik de Swart, what ALWAYS reduced childhood mortality?
 - Introduction of the measles vaccine
- 3. What protein is found on cells that are susceptible to measles?
 - CD150 (as studies on animal cells suggest)
- 4. What immune system cells produce memory cells?
 - Lymphocytes (B cells and T cells)
- 5. How much more likely were children who had been infected with measles to need another prescription for an infection? 15-24% more likely
 - a) There are statistical analyses that can be done to determine if this is significant and if there is a correlation, but in your opinion does this seem like a significant value?
 - Answers will vary
 - b) What are some other things that could impact this statistic?
 - Answers will vary

Part 5: Final Discussion

- Students can be graded on their participation during the group discussion or based on the notes taken during the discussion.
- Another option is to set this up as a Socratic seminar-style discussion where different students contribute different viewpoints.
- For the chart below, the final column (rationale and improvement suggestions) will vary

Feature	Definition	In this article?
Sensationalist Headlines	"Click bait" title- oversimplified the findings or even misinterprets them	Yes!
Misinterpreted Results	Distortion or misinterpretation of the findings of the research for the sake of a good story	Possibly
Conflicts of Interest	-Companies may employ scientists to conduct research -Research can be misinterpreted for financial or personal gain	Not obvious
Correlation & Causation	A correlation between variables doesn't always mean one causes the other	Possibly
Unsupported Conclusions	Speculation; conclusions may not be fully supported by data	Possibly
Problems with Sample Size	Smaller sample sizes reduce the confidence in the results	Yes
Unrepresentative Samples Used	If the sample doesn't represent the test population as a whole, the conclusions may be biased	Yes
No Control Group Used	Control groups help standardize results and control variables	Possibly
Selective Reporting of Data	"cherry picking"- selecting data from results that support the conclusion and ignoring those that don't	Yes
Unreplicable Results	There should be more than one independent study to support a conclusion	Not obvious
Non-Peer Reviewed Material	If it hasn't been peer-reviewed, data is not considered reputable	No