

Decoding Breast Cancer Virtual Lab

Educator Navigation Guide



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Introduction

In this virtual lab, students test tissue samples from different patients with breast cancer in order to recommend appropriate treatment. Students begin by selecting a patient and reading her unique profile. They act as virtual physicians and technicians as they conduct a series of virtual tests, gather data, and analyze the results to learn more about their patient's cancer diagnosis. Finally, students prescribe a treatment and discover whether or not their treatment approaches were successful.

As students complete the *Decoding Breast Cancer Virtual Lab*, they will refer to and record notes in a Lab Handbook. The Lab Handbook is a reference guide and a place for students to record patient information, critical data about each test and each patient's test results, and their treatment recommendations.

Objectives:

Students will:

- Analyze the relationship between chromosomes, DNA, genes, and proteins when diagnosing and treating breast cancer patients
- Analyze the relationships between each type of test and gene expression to recommend appropriate treatment for breast cancer patients
- Compare normal and abnormal cell models to explain the relationships between diagnosis and treatment

Next Generation Science Standards

LS1.A: Structure and Function

All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

LS3.A: Inheritance of Traits

Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

LS3.B: Variation of Traits

In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.

In *precision medicine*, physicians consider an individual's specific genes, medical history, environment, and lifestyle. They use these factors – along with the specific characteristics of the patient's tumor – to balance various options for treatment and prevention of diseases, including breast cancer.

Adjuvant treatment is the administration of chemotherapy, hormonal therapy, other therapy, or a combination to prevent breast cancer from returning by eradicating microscopic cancer cells that may remain after the cancer has been removed. This state-of-the-art approach reduces the chances of over-treating or under-treating breast cancer by tailoring treatment to each patient's precise needs based on the characteristics of the tumor. In this Virtual Lab, students learn about the tests doctors use to help them make precise recommendations around the treatment of breast cancer.



Meet Your First Patient — Velma Belt

In the first half of this Virtual Lab, students follow Velma Belt as she undergoes a series of tests to gather information about her breast cancer. They learn about each test, including how, why, and when it is conducted, and discover how each test provides critical information to help physicians identify appropriate treatment options for each individual. In the second half of this Virtual Lab, students apply their learning to two additional patients.

Each patient has her own medical history. As students conduct tests and gather information about their patients, they should take notes in the *Patient Record* (sample included in this guide). A *Testing and Treatment Options Organizer* has also been provided (sample included in this guide) to help students record and organize information from the Virtual Lab.

Mammogram

Mammography is a screening technique that can detect early signs of breast cancer. Students review each patient's mammogram to determine if abnormalities are present. If an abnormality is present, they identify its location and use a scale to get an idea of the abnormality's size as it compares to everyday objects.

Diagnosing Cancer

Not all abnormalities are cancerous. For each patient, students conduct tests to diagnose cancer.

Biopsy

The *biopsy* is the first step in testing whether a breast abnormality shows the presence of cancer cells. The test helps the physician decide what additional tests are necessary, if any. The biopsy enables doctors to look at the patient's cells directly. For each patient, students observe cells from a tissue sample to determine whether or not abnormal cells are present.

Surgery

Most women with breast cancer will undergo some kind of surgery to remove tissue from the area of concern. There are three main types of surgery to remove cancerous breast tissue.

- Breast-conserving surgery: Only the part of the breast that contains cancerous tissue is removed.
- Mastectomy: The entire breast is removed.

Lymph node evaluation will be done with either surgery. Surgery that conserves the breast is always the best approach unless there are factors indicating that mastectomy is required.

Pathology Report

A *pathology report* contains detailed information about the patient's diagnosis. Physicians use the information in the report to help them make decisions about the type of treatment that patient's might receive. Students review each patient's pathology report to gather additional important information.



Mammogram and Biopsy Quiz

Students take a brief quiz to check their understanding of the information they have learned about mammograms and biopsies. Correct answers are in **bold text**.

1. What is precision medicine? *Select all that apply.*
 - A. A strategy that allows doctors to more accurately predict treatment and prevention outcomes for a particular disease**
 - B. A surgical method that precisely targets a specific tumor to ensure only diseased tissue is removed
 - C. An emerging approach for cancer treatment and prevention that takes into account individual variability**
 - D. A “one-size-fits-all” approach, in which disease treatment and prevention strategies are developed for the average patient
- ☒ Note: Precision medicine is an emerging approach that allows doctors to more accurately predict treatment and prevention outcomes for a particular disease and patient.
2. Typically, the smaller the tumor, the better the chances of patient survival.
 - **True**
 - False
- ☒ Note: Typically, the chances of survival decrease with the size of the tumor. With a tumor less than 5 mm in diameter, the patient has a 95% chance of survival within 10 years. However, bear in mind that a small tumor may be more aggressive than a large tumor. If a small tumor metastasizes, the chances of survival may be lower than with a larger non-metastatic tumor.
3. All breast tumors can be medically treated in the same way.
 - True
 - **False**
- ☒ Note: Medical treatment for a tumor depends on a number of factors, including the patient’s age and medical history, as well as the size, location, and specific features of the tumor (in addition to other factors).

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Mammogram and Biopsy Quiz Continued

4. A biopsy is a non-invasive procedure.
- True
 - **False**
- ☒ Note: Since a biopsy involves extraction of the patient's live tissue, it is considered to be an invasive procedure.
5. A mammogram is a non-invasive procedure.
- **True**
 - False
- ☒ Note: Since a mammogram does not involve sampling live tissue, it is considered to be a non-invasive procedure.
6. What is a lumpectomy?
- A technique for detecting the presence of breast cancer
 - **A surgery that removes a portion of the breast**
 - A procedure involving removal of lymph nodes
 - A surgery that removes the entire breast
- ☒ Note: Lumpectomy is a surgery that removes only a portion of the breast. A mastectomy removes the entire breast.



Molecular Tissue Testing

Molecular testing is an important part of precision medicine. They evaluate DNA, genes, or proteins in tumor tissue. Genes encode proteins and proteins dictate cell function. The lab depicted in this learning module is equipped to perform the following tests:

- Estrogen Receptor Test
- HER2 FISH Test
- OncoType DX® Test

Estrogen Receptor (ER) Test

The *Estrogen Receptor (ER) Test* determines if the cells from the breast tissue have protein receptors for estrogen. The ER Test detects whether or not a specific cancer's cells express estrogen receptor protein. This test will result be reported either as positive or negative. If the test result is positive, the physician should recommend hormone blocking therapy. Students decide whether or not ER testing is necessary. If so, they conduct the test and record their patient's results

HER2 FISH Test

The *HER2 FISH Test* is another test performed on all breast cancer. FISH stands for Fluorescence in Situ Hybridization. In the HER2 FISH Test, the pathologist uses breast tissue to detect the presence of extra copies of the HER2 gene. This test will be reported either as amplified or not amplified. If the HER2 FISH results come back as amplified, the physician should recommend HER2-targeted therapy. Because HER2-targeted therapy is only given along with chemotherapy, chemotherapy would also be a part of the treatment plan. Students decide whether or not HER2 FISH testing is necessary. If so, they conduct the test and record their patient's results.

OncoType DX® Test

If a patient has an ER positive tumor, HER2 is not amplified, and no lymph nodes are involved, an *OncoType DX® Test* is needed. The OncoType DX® Test gives information about how likely it is that the tumor will spread to other parts of the body. It also helps physicians determine whether patients with early-stage invasive breast cancer will benefit from chemotherapy. This approach aims to eliminate the side-effects and costs of unnecessary treatment.

Based on the expression of 21 selected genes, a recurrence score is generated and ranges from 0-100. The higher the recurrence score, the greater the chance that the breast cancer will come back and the more likely a patient will benefit from chemotherapy.

What the Score Means

- **Lower than 18:** Low risk of recurrence with hormone therapy. The risk of side effects from chemotherapy outweighs potential benefits to the patient.
- **Between 18 and 30:** Intermediate risk of recurrence with hormone therapy. Unknown whether benefits of chemotherapy outweigh risk of side effects.
- **Greater than 30:** High risk of recurrence with hormone therapy alone. Benefits of chemotherapy outweigh risk of side effects.

Students decide whether or not OncoType DX® testing is necessary. If so, they conduct the test and record their patient's results.

Recommend a Treatment Plan

Once the patient has undergone all recommended tests, students review the test results to determine the optimal treatment plan. They should refer to their notes in the *Testing and Treatment Options Organizer* for a reminder on the appropriate treatment.

Check Your Patient's Progress

Once students have recommended a treatment approach, they learn about the patient's recovery progress. If the patient has had a recurrence of breast cancer, students should review the *Patient Record* and consult the *Testing and Treatment Options Organizer*.



Molecular Testing Quiz

Students take a brief quiz to check their understanding of the information they have learned about molecular tissue testing.

1. What is adjuvant treatment?
 - Surgical removal of tumor tissue following detection in a mammogram
 - Conducting various tests to gather information about a patient
 - **Administration of chemotherapy, hormonal therapy, other therapies or combinations of therapies to prevent breast cancer from returning**
 - Radiation treatment of tumor tissue following detection in a mammogram
- ☒ Note: Adjuvant treatment is the administration of chemotherapy, hormonal therapy, or both to prevent breast cancer from returning.
2. Which of the statements about cancer are false? *Select all that apply.*
 - **Lack of a family history of cancer means that you are risk-free**
 - **Cancer is incurable**
 - Cancer may be a genetic disease for some individuals
 - **If you stop smoking today, your cancer risk soon returns to normal**
- ☒ Note: Modern therapies have honed in on the genetic basis of cancer that increases risk for some individuals, in some cases greatly improving chances of survival. Although a family history of cancer may be associated with a higher cancer risk, no one is entirely risk-free. Someone who previously smoked, but has since quit, will have a higher risk than someone who never smoked.
3. A biopsy is conducted...
 - Only as a last resort
 - **After abnormal tissue has been found in a mammogram**
 - Through imaging breast tissue using X-rays
 - If cells with large, variable-shaped nuclei are found
- ☒ Note: A biopsy can help to confirm a possible cancer diagnosis following a mammogram. The biopsy helps the pathologist to characterize individual cells and the features of a tumor.
4. What is the best way to confirm a diagnosis of cancer?
 - Mammogram
 - **Biopsy**
 - ER Test
 - OncoType DX® Test
- ☒ Note: The biopsy allows the pathologist to observe suspect tissue at a cellular level and to characterize cells as cancerous.

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Molecular Testing Quiz Continued

5. If the ER Test is positive, it shows...

- Variation in size and shaped of cells in biopsied tissue
- Cancer cells are unlikely to respond to estrogen therapy
- Human epidermal growth factor 2 is causing tumor growth
- **Cancer cells are likely to respond to estrogen-targeting therapy**

● Note: The ER Test detects whether or not cancer cells express estrogen receptor protein, and therefore, if the cancer will respond to estrogen targeting therapy.

6. The ER Test...

- Gives a recurrence score from 0 to 100
- Is inferior to the HER2 Test
- **Is either positive or negative**
- Is based on a gene expression test

● Note: The results for the ER Test are either positive or negative.

7. The HER2 FISH Test is conducted by...

- Extracting RNA for analysis
- Identifying abnormal cells in a biopsy sample
- **Counting areas on a fluorescence micrograph**
- Analyzing cells that have lost normal specialized cell features

● Note: The HER2 FISH Test relies on fluorescence in situ hybridization, in which special colored dyes are attached to a known HER2 gene sequence. The fluorescence micrograph allows detection and counting of these gene sequences in individual cells.

8. The OncoType DX® Test...

- Identifies the number of CEP17 signals identifying chromosome 17
- **Helps physicians to make treatment recommendations**
- Determines whether or not tumor cells may respond to estrogen therapy
- Helps technicians to decide whether to extract RNA for analysis

● Note: The OncoType DX® Test helps the physician to evaluate the likelihood of recurrence and whether addition of chemotherapy to hormonal therapy is better than hormonal therapy alone. The physician can then use test results to develop recommendations for treatment of an individual's cancer.

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Molecular Testing Quiz Continued

9. The OncoType DX® Test...

- Does not require extraction of RNA for analysis
- **Conducts automated multi-gene analysis**
- Determines whether or not a biopsy is required
- Tests for the presence of a single cancer-causing gene

● Note: The OncoType DX® Test conducts an automated multi-gene analysis on 21 selected genes and calculates a score.

10. What treatment would you recommend if the OncoType DX® Test score is 10?

- Chemotherapy only
- **Hormonal therapy only**
- A combination of hormonal therapy and chemotherapy
- The score is too low to recommend a treatment

● Note: An OncoType DX® Test score of 10 indicates that the patient should receive hormonal therapy only as the risks of chemotherapy outweigh the potential benefits.



Dr. You: Meet Your Patient — Michele Johnson

Once students have completed their work with Velma Belt, they apply their learning to their next patient, Michele Johnson. They make decisions about the tests Michele will take, review her results, and make recommendations for a treatment plan.

Dr. You: Meet Your Patient — Brittany Featherston

Once students have completed their work with Michele Johnson, they apply their learning to their next patient, Brittany Featherston. They make decisions about the tests Brittany will take, review her results, and make recommendations for a treatment plan.

Testing and Treatment Options Organizer

Conduct this test when...		
ER	HR2 FISH	OncoType DX®

Treatment	Recommend this treatment option when...
Hormone blocking therapy only	
Chemotherapy followed by hormone blocking therapy	
HER2-targeted therapy and chemotherapy	
Hormone therapy and possible chemotherapy	
Hormone blocking therapy, HER2-targeted therapy, and chemotherapy	

Sample Patient Record

Patient Age: _____

Patient Gender: _____

Medical Record Number: _____

Mammography Notes

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Biopsy Notes

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Does your evaluation of the patient's tissue sample confirm the presence of cancer? YES/NO

Pathology Report

Surgical procedure:	
Date of procedure:	
Specimen size:	
Laterality:	
Tumor size:	
Margins:	
Number of lymph nodes evaluated:	
Number of lymph nodes with cancer:	

ER Test Notes

HER2 FISH Test Notes

OncoType DX® Test Notes

Treatment Approach Notes

Patient Progress Notes: