

Precision Oncology 101 ▶

What You Should Know, Ask, and Remember

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 **KNOW**  **ASK**  **REMINDER**

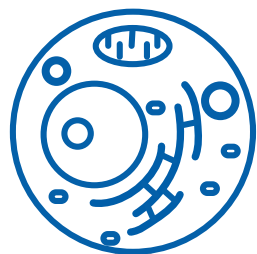


CANCER IS A UNIQUE DISEASE.

There are many different types of cancers, which is why cancer affects people differently. Additionally, there are different treatment options for different types of cancers. Different cancers all have one thing in common—they have mutations.¹

What is a mutation?

To really understand what a mutation is and how it can lead to cancer, it can help to know some biology, starting with the cell.



A cell is the smallest building block of an organism. In some ways, cells are like towns. Just as a town is full of different buildings and machines, the inside of a cell is full of different compartments and molecular machines that each have their own function.²



Proteins are needed for a cell to function. Some proteins use energy to do a specific job, like a machine. Other proteins provide structure to the cell, like the frame of a building.²



DNA has the information needed to make everything in the cell. It is similar to a book of blueprints for every building and machine in a town. A **gene** is a region of DNA, like a page in a book of blueprints. Most genes have information needed to make a specific protein.^{2,3}



A mutation is a change in the DNA sequence⁴



Some mutations change how a protein does its job, which can alter the way the cell works. Other mutations have no effect at all.⁵



There are **thousands** of different mutations that can lead to cancer.⁶



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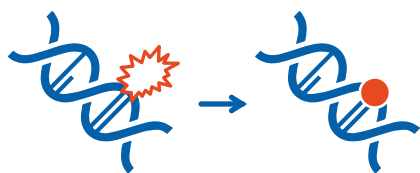


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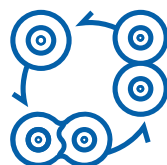


What causes a mutation?

Mutations may be caused by^{4,7}:



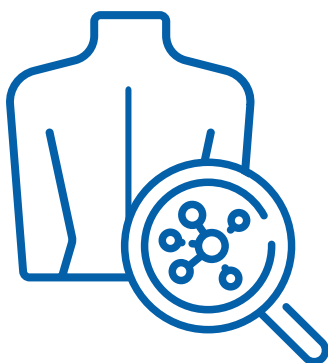
Exposure to something that can damage DNA.



Cell division, a normal process when 1 cell becomes 2.

2/3 of the mutations leading to cancer occur during cell division.⁷

Mutations are random



They can be in any part of the DNA and can occur in any cell in the body.⁸

Mutations leading to cancer make cells grow and divide uncontrollably.^{7,9,10}

This means that cancer cells can get even more mutations over time.¹⁰



Most of these new mutations will have no impact on the cancer, but some may change the way the cancer behaves.^{9,10}



Cancer therapies kill cancer cells or stop them from dividing.^{4,11-14}



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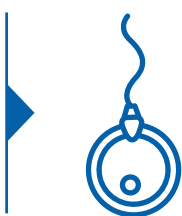
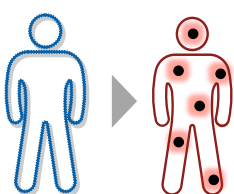
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If a mutation caused my cancer, does that mean my family or children will get this cancer too?



Genes can be inherited or passed down to children. This is why there may be some traits that run in your family. However, not all mutations are inherited^{4,8}



Inherited mutations (aka, germ-line mutations):^{4,8}

- Occur in the sperm or eggs
- Are present at conception
- Exist in every cell in your body

Not inherited mutations (aka, somatic mutations):^{4,8}

- Occur in any other type of cell
- Happen over the course of your life
- Are present in some cells in your body



92%

of cancer-causing mutations were mutations that were not inherited (somatic mutations) in one study^{7,15}

This means your family may not have a higher risk of getting cancer. However, genetic testing for an inherited mutation may help your family know if they have a higher risk for cancer.



Ask your oncology health care provider (HCP) if genetic testing for an inherited mutation is right for you.



How does this information impact my care?

Some – but not all – mutations are **biomarkers**. **Biomarkers can provide important information for your cancer care.**



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WHAT IS A BIOMARKER?

A **biomarker** is a molecule found in bodily fluids or tissues that is a sign of how the body is working or is a marker for a condition or disease. A biomarker can be a specific mutation, protein, or molecule.¹⁷⁻¹⁹

In cancer, **biomarkers may provide clues about the cancer**, how it acts, and how it may behave in the future. These biomarkers may be made by the cancer itself or by other cells in the body as a response to the cancer.¹⁹

5 TYPES OF BIOMARKERS^{18,19}

▶ 1

Diagnostic biomarkers can be used to tell if a person has a disease

- Diagnostic biomarkers can be one of the first signs of cancer

2 ◀

Predictive biomarkers may help identify patients that may benefit from a specific therapy

- Predictive biomarkers may help your health care team pick a treatment for your cancer.

▶ 3

Prognostic biomarkers may help forecast the course of the disease

- Prognostic biomarkers may help identify patients more likely to experience disease recurrence.

4 ◀

Monitoring biomarkers may help understand how a disease is changing over time

- Monitoring biomarkers may help your health care team know if your cancer is responding to treatment. Monitoring biomarkers may be a sign that your cancer has come back.

▶ 5

Risk and susceptibility biomarkers may be able to identify patients that *might* get a disease

- Risk and susceptibility biomarkers may help identify people who are more likely to get cancer. Some risk and susceptibility biomarkers are inherited mutations. In some cases, your HCP may recommend genetic testing for an inherited mutation to see if your family has a higher risk of getting cancer.



Actionable biomarkers help your oncology care team understand your cancer and make decisions about your treatment.



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How will I know if I have a biomarker?

You can only know if you have a biomarker if you are tested for it. During biomarker testing, the pathologist will perform a molecular test on a biopsy sample to see if you have a biomarker²⁰



There are many different types of molecular tests. Biomarker tests can:^{19,21}



Look for mutations in DNA

OR



Measure the amount of a specific protein

OR



Detect a molecule associated with the cancer

The number of biomarkers tested in one test can vary. Biomarker tests can:^{19,21}



Look at one biomarker at a time

OR



Look at many biomarkers at once

What biomarkers will I be tested for?

There are different biomarkers for different types of cancers. For example, as of January 2022, there are:



10 predictive biomarkers in non-small cell lung cancer²²⁻²⁴



6 predictive biomarkers in metastatic breast cancer²⁵



You may not be tested for all recommended biomarkers automatically.

Find out the important biomarkers for your type of cancer and talk to your oncology care team about testing for these markers. Make sure to ask about the results.



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When will I be tested for a biomarker?

Biomarker testing may occur at different times during the course of your treatment journey.^{18,20}

It is important to remember that all cancers are different. Your cancer may not become resistant or recurrent.

You may have biomarker testing^{18,20}



How long does biomarker testing take?

The time it takes to get the results from biomarker testing varies.^{26,27}



The number of tests and the type of test will impact how long it takes to get results back. It can take anywhere from 2 days to weeks to get test results.

◆ 1 Test

⚙️ 1 Biomarker

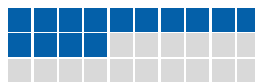
Days to result



◆ 1 Test

⚙️⚙️ Many biomarkers

Days to result



◆◆ Multiple tests

⚙️ 1 Biomarker

Days to result



The figures above are examples and do not represent the time to result for a specific test.



Even though some biomarker test results may take longer than others to return, it is important to wait for biomarker test results before starting or changing your treatment plan when possible.



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What is a biopsy?

A **biopsy** is a medical procedure to collect a small sample of cells^{28,29}



These cells are examined to^{28,29}:

- Confirm your cancer diagnosis
- Determine the stage (or extent) of your cancer
- Understand the biology of your cancer

You may have a biopsy at^{20,29}:

○ **Diagnosis**

○ **Resistance**

○ **Recurrence**

Treatment journey

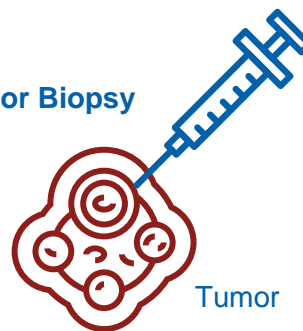
You may also have a biopsy if your oncologist wants to perform more biomarker testing at any point during your treatment journey²⁰

There are 2 types of biopsies: **tumor biopsy** and **liquid biopsy**.

What is a tumor biopsy?

A **tumor biopsy** is a procedure where a doctor removes a sample of the tumor with a needle or surgery.²⁹

Tumor Biopsy



Tumor biopsies can^{20,29}

- Tell the doctor what kind of cancer you have
- Determine how aggressive your cancer is
- Be tested for biomarkers to help your doctor decide the best therapy for your cancer



Getting a tumor biopsy does not guarantee that you will be tested for every biomarker specific to your type of cancer.



Sometimes, it may not be possible to get a tumor biopsy, or the tumor biopsy cannot be used for biomarker testing. In this situation, your doctor may suggest a “liquid biopsy”.



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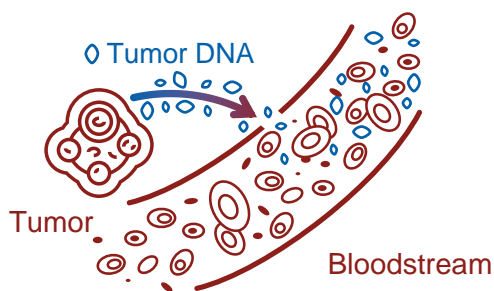
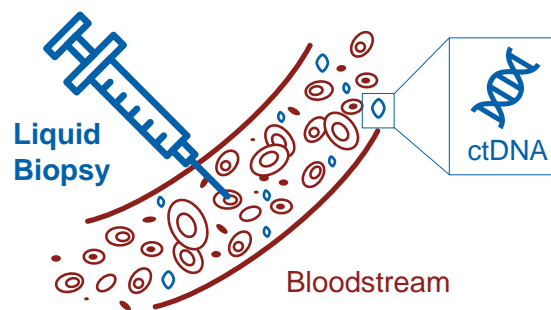


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What is a liquid biopsy?

A **liquid biopsy** is a procedure where doctors draw blood to look for cancer cells or cancer-causing mutations.^{30,31}



Liquid biopsies are possible because cancer cells may release small amounts of their DNA into your blood.^{30,31}

These small pieces of DNA are called circulating tumor DNA, or ctDNA. ctDNA can be detected by some biomarker tests.^{30,31}

Liquid biopsies can:^{30,31}

- Be tested for biomarkers to help your doctor decide the best therapy for your cancer
- Help determine if you are responding to therapy



A liquid biopsy test may miss mutations that cause cancer.³⁰ If you have a negative result from a liquid biopsy test, talk to your oncology HCP about tumor biopsy testing.



In some cases, you may have a traditional tumor biopsy and a liquid biopsy at the same time. Testing both types of biopsies may make it more likely to find a mutation leading to your cancer.³² Your HCP may recommend starting treatment based on the liquid biopsy test results while waiting for the tumor biopsy results.



No matter what type of biopsy you have, ask your oncology care team about biomarker testing to make sure you are tested.



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What are my treatment options?

There are many different types of treatments for cancer. Some cancers may respond to one therapy and not another. The type of cancer, the stage of your cancer, and biomarker test results may help your care team identify potential therapies for your cancer.

Some types of cancer therapies



Chemotherapy¹¹ works by stopping cancer cells from growing or dividing. Side effects occur because chemotherapy also stops normal cells from growing and dividing.



Immunotherapy^{12,33} works by helping your immune system recognize cancer cells. The immune system can then kill the cancer cells. Side effects occur if the immunotherapy causes your immune system to mistake normal cells for cancer cells.



Radioligand therapy^{13,34} works by delivering targeted radiation to the tumor, which causes DNA damage and inhibits tumor growth and replication. Side effects occur if the radioisotope is delivered to non-cancerous cells adjacent to the tumor.



Targeted therapy^{14,35} works by preventing a gene or protein that impacts cancer growth from functioning. Side effects occur if the targeted therapy negatively impacts normal cells using these proteins.

All cancer therapies have a risk of side effects. No matter what treatment you receive, **it is important to talk to your care team if you experience side effects.** They can help you manage your side effects so that you can potentially stay on treatment longer.



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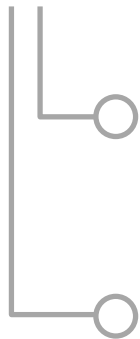


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A therapy was prescribed. Now what?

Taking your therapy as prescribed is extremely important.
A medicine cannot work if you do not take it.



Patients who take their medicine as directed may be **more likely to respond** to therapy and have **better long-term outcomes.**³⁶⁻³⁹



Not taking an oncology medicine as prescribed may be linked to **unnecessary hospitalizations.**⁴⁰

Side effects can make it harder to keep up with your treatment.

Side effects can occur with any anticancer medication. Please tell your health care team about any side effects so they can manage your side effects.



Self care:

Your oncologist and health care team can teach you how to manage some side effects. Patients who learn how to manage their side effects are more likely to stay on the medication.⁴¹



Dose adjustments:

In some cases, your oncology HCP may reduce the dose of the medication or temporarily stop the medication.



Tell your oncology care team immediately if you experience side effects. They may offer suggestions to help manage side effects to support staying on treatment.



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How can I avoid missing a dose?

Most people have a hard time taking their medication as prescribed.⁴⁰ These tricks can help.^{42,43}



Alarms

Some medications may need to be taken at the same time each day.

A daily alarm (either on a cell phone or on a clock in your house) can help you remember to take your medication at that time.



Calendars/ Checklists

Using a calendar/checklist that you can mark each time you take your medication as prescribed can help you remember to take your medication.

Calendars can also help you remember when you need to get a refill, to ensure that you are never out of medication.



Pill Boxes

Sometimes you can forget if you took your medication that day.

Pill boxes can help you remember if you took your medication.



Smartphone Apps

Some treatments are complicated and require multiple medications taken throughout the day.

Some smartphone apps can help remind you to take each medicine at the appropriate time. Some apps can also help remind you to get refills or keep track of symptoms.



It is important to take your medication as prescribed. A medication cannot work if you don't take it.⁴²



Talk to your health care team if you are having trouble keeping up with your medication or experiencing side effects.



KNOW



ASK



REMINDER



Where can I find more information?

Because there are so many different types of cancers and treatment options, it is important to find out as much as you can about your cancer before starting treatment. Biomarker testing can help your care team understand your cancer and pick the best treatment for you. It is important to remember that no matter what treatment you receive, side effects can occur. Be sure to speak with your care team about any side effects you experience.

For more information on cancer biology, biomarker testing, and treatment options, please see:

<https://www.cancerquest.org/patients/what-cancer>

<https://www.cancer.net/navigating-cancer-care>

<https://www.cancer.gov/about-cancer/>

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References: 1. National Cancer Institute. What is cancer? <https://www.cancer.gov/about-cancer/understanding/what-is-cancer>. Accessed October 13, 2021. 2. O'Connor CM, Adams JU. *Essentials of Cell Biology*. Cambridge, MA: NPG Education; 2010. 3. National Cancer Institute. <https://www.cancer.gov/publications/dictionaries/genetics-dictionary/def/gene>. Accessed November 1, 2021. 4. National Human Genome Research Institute. Talking glossary of genetic terms: mutation. <https://www.genome.gov/genetics-glossary/Mutation>. Accessed October 4, 2021. 5. Nishant KT et al. *Bioessays*. 2009;31(9):912-920. 6. Bailey MH et al. *Cell*. 2018;173(2):371-385.e18. 7. Tomasetti C et al. *Science*. 2017;355(6331):1330-1334. 8. Scitable. Genetic mutation. <https://www.nature.com/scitable/topicpage/genetic-mutation-1127/>. Accessed October 20, 2021. 9. Greenman C et al. *Nature*. 2007;446(7132):153-158. 10. Greaves M et al. *Nature*. 2012;481(7381):306-313. 11. National Cancer Institute. Chemotherapy to treat cancer. <https://www.cancer.gov/about-cancer/treatment/types/chemotherapy>. Accessed October 7, 2021. 12. National Cancer Institute. Immunotherapy to treat cancer. <https://www.cancer.gov/about-cancer/treatment/types/immunotherapy>. Accessed October 7, 2021. 13. Targeted radionucleotide therapy. Advancing Nuclear Medicine Through Innovation. <https://www.ncbi.nlm.nih.gov/books/NBK11464/>. Accessed November 1, 2021. 14. National Cancer Institute. Targeted therapy to treat cancer. <https://www.cancer.gov/about-cancer/treatment/types/targeted-therapies>. Accessed October 7, 2021. 15. Huang KL et al. *Cell*. 2018;173(2):355-370.e14. 16. Bhullar KS et al. *Mol Cancer*. 2018;17(1):48. 17. National Cancer Institute. NCI dictionary of cancer terms: biomarker. <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/biomarker>. Accessed October 4, 2021. 18. FDA-NIH Biomarker Working Group. BEST (Biomarkers, EndpointS, and other Tools) Resource. Silver Spring, MD: Food and Drug Administration (US); 2016. <https://www.ncbi.nlm.nih.gov/books/NBK326791>. Accessed August 27, 2020. 19. Goossens N et al. *Transl Cancer Res*. 2015;4(3):256-269. 20. National Cancer Institute. Biomarker testing for cancer treatment. <https://www.cancer.gov/about-cancer/treatment/types/biomarker-testing-cancer-treatment>. Accessed October 13, 2021. 21. Roychowdhury S et al. *CA Cancer J Clin*. 2016;66(1):75-88. 22. Thai AA et al. Lung Cancer. *Lancet*. 2021;398(10299):535-554. 23. Chakravarty D et al. *J Clin Oncol*. 2022;40(11):1231-1258. 24. Hanna NH et al. *J Clin Oncol*. 2021;39(9):1040-1091. 25. Najjar S et al. *Vichows Arch*. 2022. doi:10.1007/s00428-022-03267-x. 26. Pennell NA et al. *Am Soc Clin Oncol Educ Book*. 2019;39:531-542. 27. Pennell NA et al. *JCO Precision Oncol*. 2019. DOI:10.1200/PO.18.00356. 28. Lee K et al. *PLoS One*. 2019;14(8):e0221065. 29. Mayo Clinic. Biopsy: types of biopsy procedures used to diagnose cancer. <https://www.mayoclinic.org/diseases-conditions/cancer/in-depth/biopsy/art-20043922>. Accessed October 7, 2021. 30. Merker JD et al. *J Clin Oncol*. 2018;36(16):1631-1641. 31. De Rubis G et al. *Trends Pharmacol Sci*. 2019;40(3):172-186. 32. Mack PC et al. *Cancer*. 2020;126:3219-3228. 33. Morrissey KM et al. *Clin Transl Sci*. 2016;9(2):89-104. 34. Jadvar H. *AJR Am J Roentgenol*. 2017;209(2):277-288. 35. Falzone L et al. *Front Pharmacol*. 2018;9:1300. 36. Noens L et al. *Blood*. 2009;113(22):5401-5411. 37. Marin D et al. *J Clin Oncol*. 2010;28(14):2381-2388. 38. Hershman DL et al. *Breast Cancer Res Treat*. 2011;126(2):529-537. 39. Ganesan P et al. *Am J Hematol*. 2011;86(6):471-474. 40. Partridge AH et al. *J Natl Cancer Inst*. 2002;94(9):652-661. 41. Jiang Y et al. *Patient Prefer Adherence*. 2019;13:2243-2252. 42. Schneider SM et al. *Semin Oncol Nurs*. 2011;27(2):133-141. 43. Greer JA et al. *J Natl Compr Canc Netw*. 2020;18(2):133-141. 44. National Cancer Institute. Cancer staging. <https://www.cancer.gov/about-cancer/diagnosis-staging/staging>. Accessed October 15, 2021. 45. National Cancer Institute. NCI dictionary of cancer terms: refractory cancer. <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/refractory-cancer>. Accessed October 15, 2021. 46. National Cancer Institute. NCI dictionary of cancer terms: recurrent cancer. <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/recurrent-cancer>. Accessed October 15, 2021.



Glossary

- **Cancer** is a unique disease caused by uncontrolled cell growth¹
- A **cell** is the smallest building block of an organism²
- **Proteins** help cells function and survive²
 - Proteins can use energy to do a specific job or can help provide structure to the cell
- **DNA** has the information needed for a cell to function²
- A **gene** is a region of DNA that has the information needed to make a specific protein³
- A **mutation** is a change in the DNA sequence⁴
 - A **germ-line mutation** is inherited and may be passed down to your children
 - A **somatic mutation** is not inherited and cannot be passed down to your children
- A **cancer cell** has a mutation that makes it grow and divide uncontrollably¹
- A **tumor** is a large group of cells¹
- The **stage** of your cancer refers to the extent of your cancer⁴⁴
 - It is based on the size of your tumor and how much it has spread. The lower the stage, the less cancer you have
- **Metastasis** occurs when part of the original tumor moves to a different part of the body¹
- Your cancer is **resistant** if it has stopped responding to treatment⁴⁵
- Your cancer is **recurrent** if it has come back⁴⁶
- A **biopsy** is a medical procedure to collect a small sample of cells. These cells are examined to confirm your diagnosis of cancer and to get more information about your cancer²⁷
 - A **tumor biopsy** is a procedure where a doctor removes a sample of the tumor with a needle or with minor surgery²⁹
 - A **liquid biopsy** is a procedure where doctors draw blood to look for cancer cells or cancer-causing mutations³¹
- A **biomarker** is something that can be measured and signals how the body, or part of the body, is working or may work in the future¹⁷
- A **biomarker test** is needed to look at a biomarker and get information on how the body is working²⁰



