

## Melanoma and the BRAF V600E Mutation

This material will help you understand:

- the basics of melanoma
- the role of the BRAF gene in melanoma
- if there are any drugs that might work better if you have certain changes in the BRAF gene

### What is melanoma?

Melanoma is a type of skin cancer. It starts in the cells that make melanin, the substance that gives skin its color.

### What causes melanoma?

Cancer is caused by changes in our genes. Genes contain the instructions for making proteins. Changes in genes, called mutations, may result in changes in proteins. These changes may cause cells to grow out of control which could lead to cancer.

Melanoma usually starts on areas of the skin exposed to the sun. But melanoma can also show up in other parts of your body like the eye, the bottom of the feet, under the nails, or inside the mouth.



### What are the most common current treatments for melanoma?

Doctors may treat melanoma using one or more of these options:

- **Surgery** – operation that removes as much of a cancer tumor as possible.
- **Traditional chemotherapy** – drugs that kill growing cells. All cells grow, but cancer cells grow faster than healthy cells. So, these drugs kill more of the cancer cells. But because these drugs kill healthy cells too, this can cause unwanted side effects.
- **Precision medicine therapy** – treatments that target proteins involved in cancer.

These therapies mainly kill cancer cells and not healthy cells. This also means you may have fewer side effects. Two types of precision medicine therapies are:

- **Small molecule therapy** – mainly acts on cells with specific protein changes. Small molecule therapy uses drugs to target those proteins. Genetic testing can tell if your cancer cells have protein changes that can be targeted. Small molecule therapy is a type of targeted therapy.
- **Immune-based therapy** – works with your body's defense system to fight cancer. These can mark cancer cells so they are easier for your immune system to find.



## Can I pass on mutations found in my cancer cells to my children?

You cannot pass on mutations found only in your cancer cells to your children.

## How well does cancer drug treatment work?

After a while, your cancer cells may stop responding to the drug(s). This means your cancer may start to grow again. Your doctor will do regular checkups to watch for this. If the cancer starts to come back, your doctor can try another drug or treatment.



## What is BRAF?

BRAF (pronounced “B-răf”) is the name of both a gene and a protein. The BRAF gene contains the instructions for making the BRAF protein. BRAF is a member of the RAF family of proteins. Their main job is to help control cell growth. RAF proteins are part of a pathway. Proteins in pathways work together to do specific jobs within the cell. Some of the other proteins in this pathway include RAS, MAP2K1 and ERK. This is shown in the healthy cell image below (Figure 1). This pathway is a signaling pathway. It passes signals from outside the cell to the cell’s nucleus. The nucleus is the control center of the cell. These signals may tell the cell to grow, divide, or die. These are all normal cell functions. The body turns the signals on and off as needed.

## What is BRAF’s role in the growth pathway?

In healthy cells, the growth signal turns proteins “on.” As the signal reaches each protein in the pathway, it turns on the protein. BRAF receives the signal via RAS. BRAF passes it on to MAP2K1, and MAP2K1 passes it on to ERK. ERK is the last protein in the pathway. When ERK is on, it turns on genes in the nucleus that help cells grow. When the signal stops, the proteins turn off.

## How do mutations in proteins affect pathways?

If a mutation affects one or more proteins in a pathway, the proteins may not be able to be turned on or off as expected. This can cause cells to grow out of control and lead to cancer.

## How common are BRAF mutations in melanoma?

About half of all melanomas have a mutation in the BRAF gene that changes the BRAF protein. BRAF mutations are most common in melanomas found on skin without long-term sun damage. But these mutations can occur in all types of melanoma.

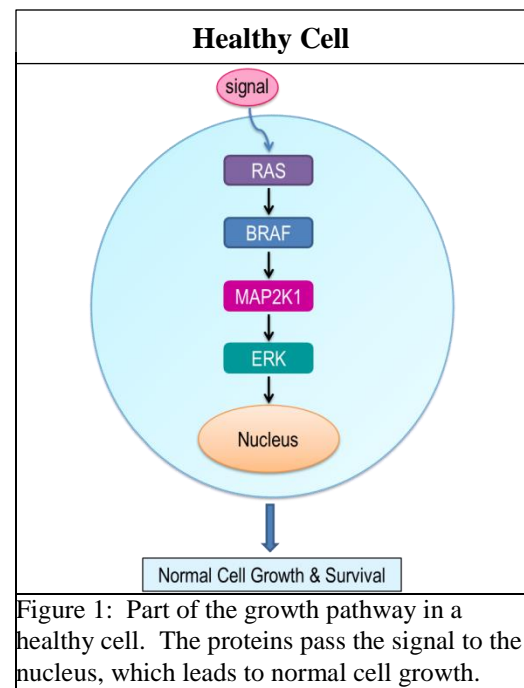
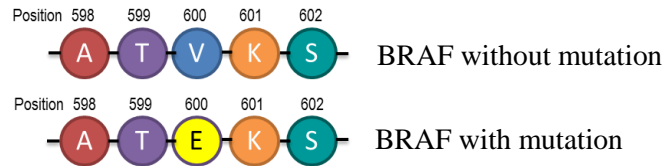


Figure 1: Part of the growth pathway in a healthy cell. The proteins pass the signal to the nucleus, which leads to normal cell growth.

### What is the BRAF V600E mutation?

V600E is a specific variation in the BRAF protein<sup>📄</sup>. Proteins are long chains of amino acids<sup>📄</sup>. The BRAF protein has 766 amino acids. BRAF with no mutation<sup>📄</sup> at amino acid position 600 has a valine, or V for short. The amino acid at position 600 in BRAF with the V600E mutation is a glutamic acid, or E for short. V600E is the most common BRAF mutation in melanoma.



### What is the effect of this mutation?

The V600E mutation<sup>📄</sup> is in the part of BRAF that passes along the cell growth signal. In cells with this mutation, BRAF can always turn on MAP2K1. This keeps the growth pathway on. Cells with this mutation can grow out of control, which can lead to cancer (Figure 2).

### Are there targeted therapies<sup>📄</sup> for BRAF V600E?

The BRAF V600E mutation<sup>📄</sup> is a target for BRAF inhibitor drugs. The drugs dabrafenib and vemurafenib are BRAF inhibitors. These drugs stop the BRAF protein<sup>📄</sup> with the mutation from turning on MAP2K1 (Figure 3). MAP2K1 is another protein in this cell growth pathway.

BRAF inhibitors work well. But, after a while, your cancer cells may stop responding to these drugs. So, your doctor may also prescribe a MAP2K1 inhibitor drug. MAP2K1 inhibitors keep MAP2K1 from turning on ERK. Trametinib, selumetinib, and cobimetinib are common MAP2K1 inhibitors that may work well in cancer cells with BRAF mutations. Taking both a BRAF and a MAP2K1 inhibitor helps make sure this growth pathway is off. The drugs inhibit the growth of cells with this mutation and may lead to cell death. You should talk to your doctor about your treatment options.

### What if I have a different mutation in BRAF or “no mutation”?

Your cancer cells might have mutations<sup>📄</sup> in this gene<sup>📄</sup> or in other genes that were not tested. Your genetic test<sup>📄</sup> results will still help your doctor determine the best treatment for you.

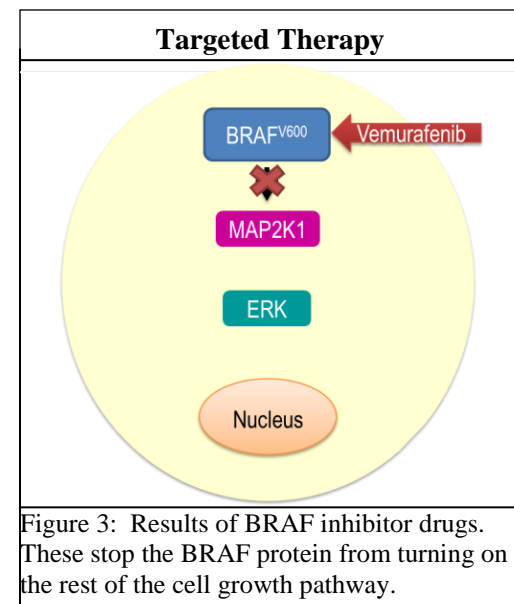
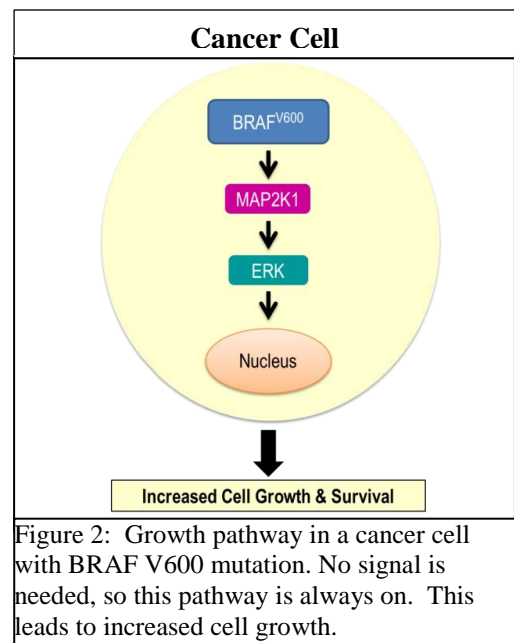


Figure 2: Growth pathway in a cancer cell with BRAF V600 mutation. No signal is needed, so this pathway is always on. This leads to increased cell growth.

Figure 3: Results of BRAF inhibitor drugs. These stop the BRAF protein from turning on the rest of the cell growth pathway.