The background is a gradient from dark purple at the top to deep blue at the bottom, speckled with white dots resembling stars. Overlaid on the left side are several concentric circular patterns, some solid and some dashed, with arrows indicating clockwise or counter-clockwise movement. A large circular scale with numerical markings from 140 to 260 in increments of 10 is also visible on the left.

QUARTER 4 – MODULE 4: ANTICANCER DRUGS

WHAT I NEED TO KNOW

- This module was designed and written with you in mind. It is here to help you master the properties, mode of action and effects of anticancer drugs. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.
- This learning module is aligned with the learning competency:
- describe the properties, mode of action and effects of anticancer drugs.
- After going through this module, you are expected to:
- describe the anticancer drug and its properties;
- describe the mode of action and the effects of anticancer drug; and
- explain the effects and side effects of anticancer drugs to cancer cells.

WHAT I KNOW

1. What does the “total cell-kill” mean in chemotherapy?

- a. It is the process of reducing cancer cells.
- b. It is a surgical process and drug treatment for 5 years.
- c. It is a treatment of the DNA of the cancer cell by eliminating the nitrogen bases.
- d. It is the removal of tumor by surgical process and destruction of cancer cells through radiation therapy.

2. What happens to a patient’s body during chemotherapy?

- a. It decreases the tumor mass by 100 mg.
- b. It targets cells that grow and divide quickly.
- c. It can reduce the tumor mass by 99.99% by surgical process.
- d. It can identify the cancer cells and destroy the cell division process.

- 3. How do alkylating agents affect cancer cells?
 - a. It reduces the tumor mass by 99.99%
 - b. It reduces the damage of the cancer cells.
 - c. It keeps the cancer cell into one area and kills it.
 - d. It stops the cancer cell from reproducing by damaging its DNA.
- 4. Which anticancer drug is used to treat severe psoriasis and rheumatoid?
 - a. Bleomycin
 - b. Daunorubicin
 - c. Doxorubicin
 - d. Methotrexate

- 5. How does cyclophosphamide work to treat cancer?
 - a. It slows down the cell division of cancerous cells.
 - b. It strengthens the immune system of the patient.
 - c. It helps produce good cells and replace the damaged ones.
 - d. It scrambles the DNA of cancer cells and may damage the healthy cells.
- 6. Which is the first approved chemotherapy drug in 1962?
 - a. Doxorubicin
 - b. Daunorubicin
 - c. Fluorouracil
 - d. Paclitaxel

- 7. What anticancer drug can be prescribed to a patient with a pancreatic cancer that has spread or is inoperable?
 - a. Bleomycin
 - b. Gemcitabine
 - c. Doxorubicin
 - d. Methotrexate
- 8. Which of the following can be used as anticancer drug but could weaken the heart of a patient?
 - a. Bleomycin
 - b. Daunorubicin
 - c. Doxorubicin
 - d. Methotrexate

ANTICANCER DRUGS

•Sunshine may prevent cancer

- Sunshine is back in the good books of medical practitioners and dermatologists. New research suggests that fifteen minutes a day of direct exposure to sunshine may be beneficial in the prevention and treatment of many forms of cancer. Researchers point to the fact that there is a lower incidence of prostate, colon and breast cancers in sunnier parts of the world.
- Dr. Edward Giovannucci of Harvard University suggests that vitamin D, also known as the “sunshine vitamin”, might help prevent 30 deaths for each one caused by skin cancer. He said: "I would challenge anyone to find an area or nutrient or any factor that has such consistent anti-cancer benefits as vitamin D."
- Plastering our bodies in sunscreen to avoid skin cancers, such as melanoma, may be more harmful than direct exposure to the sun. Sunscreen blocks UV rays and therefore inhibits the vital production of vitamin D. Our skin absorbs the rays and produces vitamin D. Melanoma, the deadliest kind of skin cancer, accounts for just 1.4 per cent of all cancer deaths.

TRUE / FALSE

- a. Scientists have told us for many years that sunshine is healthy.
- b. Researchers say there is a link between studying and cancer.
- c. Doctors and scientists have changed their minds about UV rays.
- d. Vitamin C is called the “sunshine vitamin”.
- e. Vitamin D may prevent 30 deaths for each one caused by skin cancer.
- f. Sunscreen might not be so necessary now.
- g. Our bodies need five hours a day in direct sunlight.
- h. There is less cancer in sunnier parts of the world.

WHAT'S NEW

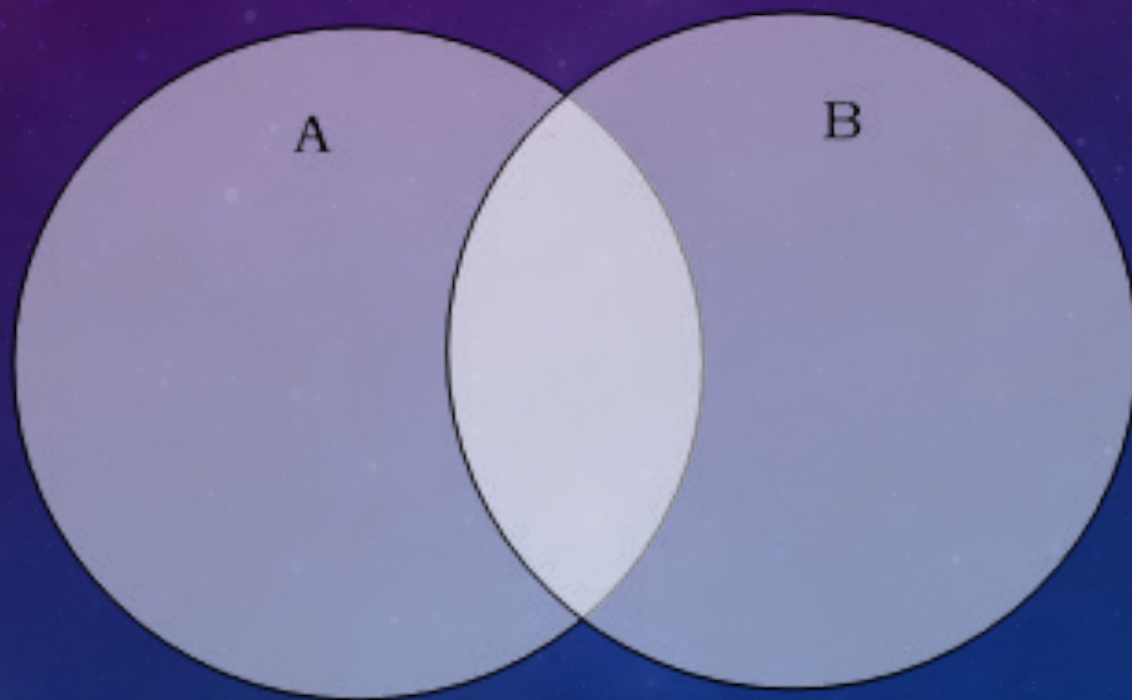


- Naked mole rats can live for an incredibly long time and have an exceptional resistance to cancer thanks to unique conditions in their bodies that stop cancer cells from multiplying.
- Researchers at the University of Cambridge suggests that what sets naked mole-rats apart is the microenvironment - the complex system of cells and molecules surrounding a cell, including the immune system. The researchers believe interactions with this microenvironment are what stop the initial stages of cancer from developing into tumours, rather than a cancer resistance mechanism within healthy cells as previously thought.

- On the other hand, molecular and cell biologist Vera Gorbunova of the University of Rochester in New York discovered that the secret to this rodent's good health is a complex sugar called hyaluron that keeps cells from clumping together and forming tumors. Hyaluron exists in all animals, helping lubricate joints and serving as an essential component in skin and cartilage. It's been used in skin lotions and anti-arthritis treatments, and some forms have even been proposed to promote cancer. In addition, the researchers discovered that the enzyme that breaks down this sugar is not very active in naked mole rats, allowing the compound to accumulate to higher concentrations than it does in other animals. The researchers think that this sugar evolved to make naked mole rat skin more elastic and able to cope with the tight squeeze of the narrow underground tunnels.

DIRECTION: ANSWER THE FOLLOWING QUESTIONS:

- 1. What happens to cancer cells in naked mole rats?
- 2. What is hyaluron?
- 3. How does hyaluron affect the naked mole rat?
- 4. By using a Venn diagram, distinguish the characteristics of naked mole rats (A) from other rats (B)?



WHAT IS IT

- Anticancer drug
- Anticancer drug, also called antineoplastic drug, is any drug that is effective in the treatment of malignant, or cancerous, disease. There are several major classes of anticancer drugs - alkylating agents, antimetabolites and anthracycline antibiotics. In addition, there are a number of drugs that do not fall within those classes but that demonstrate anticancer activity and thus are used in the treatment of malignant disease.



- Drug treatment for cancer is called chemotherapy. The job of chemotherapy is to destroy cancer cells, including those that may have spread beyond the main tumor. Unlike surgery or radiation, most types of chemotherapy, or "chemo," don't target a particular tumor or a particular part of the body, although there are some newer "designer drugs" being developed that seek out and destroy cancer cells specifically. Most forms of chemotherapy attack all rapidly dividing cells, and cancer cells fit that description.
- When fighting cancer, the entire population of neoplastic cells - abnormal growth of cells must be eradicated in order to obtain desired results. The concept of "total cell-kill" applies to chemotherapy as it does to other means of treatment: total excision of the tumor is necessary for surgical care, and complete eradication of all cancer cells is required for a cure with radiation therapy. By investigation of a model tumor system, the L1210 leukemia of mice, a number of important principles have been established as follows:

- 1. A single clonogenic malignant cell can give rise to sufficient progeny to kill the host; to achieve cure it is thus necessary to destroy every such cell. Since the doubling-time of most tumors is relatively constant during logarithmic growth, the life-span of the host is inversely related to the number of malignant cells that are inoculated or that survive therapeutic measures.
- 2. The cell-kill caused by antineoplastic agents follows first-order kinetics, that is, a constant percentage, rather than a constant number, of cells is killed by a given therapeutic maneuver, this finding has had a profound impact on clinical cancer chemotherapy. For example, a patient with advanced acute lymphocytic leukemia might harbor 10^{12} or about 1 kg of malignant cells. A drug killing 99.99% of these cells would reduce the tumor mass to about 100mg, and this would be apparent as a complete clinical remission. However, 10^8 malignant cells would remain, any of which could cause a relapse in the disease.

MAJOR CLASSES OF ANTICANCER DRUGS

- 1. **Alkylating agents** are compounds that work by adding an alkyl group to the guanine base of the DNA molecule, preventing the strands of the double helix from linking as they should. This causes breakage of the DNA strands, affecting the ability of the cancer cell to multiply. Eventually, the cancer cell dies. The primary mode of action for most alkylating drugs is via cross-linking of DNA strands. They can be classified as either monofunctional alkylating agents, implying reactions with only one strand of DNA, or bifunctional alkylating agents, which cross-link two strands of DNA. Replication of DNA and transcription of RNA are prevented by these cross-links. All alkylating agents depress bone marrow function and cause gastrointestinal disturbances such as nausea and vomiting. As bone marrow is responsible for the production of red blood cells, white blood cells and platelets when it is weakened symptoms of anemia, infection and bleeding respectively, may occur. In rare cases, this can lead to leukemia. The risk of leukemia from alkylating agents is “dose-dependent,” meaning that the risk is small with lower doses, but goes up as the total amount of the drug used gets higher. The risk of leukemia after getting alkylating agents is highest about 5 to 10 years after treatment.
- Alkylating agents play a significant role in the treatment of lymphoma, Hodgkin's disease, breast cancer, multiple myeloma, and other malignancies. Anticancer drugs that contain alkylating agents are cyclophosphamide, ifosfamide, melphalan, and chlorambucil.

- **2. Antimetabolites** are called a “cytotoxic” type of drug because they kill cells. They work by mimicking the molecules that a cell needs to grow. Cells are tricked into taking in the drugs and then using the antimetabolites instead of their normal building blocks of genetic material: RNA and DNA. With the drugs on board, the cells can no longer copy their DNA, so they can’t divide into new cells. Because antimetabolites target cells only as they are dividing, these medications are most effective against tumors that are growing quickly. The benefit of taking antimetabolite drugs to treat cancer is that the drugs kill cancer cells, which can help you live longer and make your tumor stop growing or shrink. But antimetabolites don’t work for everyone, and it can be hard for doctors to predict whose tumors will respond to these drugs. Even when antimetabolites first work well, tumors often become resistant to this drug, which means they eventually don’t work anymore.
- Hypomethylating agents represent a class of drugs that may restore normal gene function to genes responsible for cell division and differentiation. Hypomethylating agents may function as biological response modifiers by affecting cytokine cell signaling. These agents may be identified as antimetabolites and they include 5-azacytidine and Decitabine.
- Methotrexate is used to treat certain types of cancer of the breast, skin, head and neck, or lung. Methotrexate is also used to treat severe psoriasis and rheumatoid arthritis. Other examples include 5-Fluorouracil and Cytosine Arabinoside.

- 3. **Anthracyclines or anthracycline antibiotics** are a class of drugs used in cancer chemotherapy derived from *Streptomyces* bacteria (more specifically, *Streptomyces peucetius* var. *caesius*). These compounds are used to treat a wide range of cancers, including leukemias, lymphomas, and breast, uterine, ovarian, and lung cancers. Examples include Bleomycin, Daunorubicin, and Doxorubicin.
- Anthracycline has three mechanisms of action:
 - 1. inhibits DNA and RNA synthesis by intercalating between base pairs of the DNA/RNA strand, thus preventing the replication of rapidly-growing cancer cells,
 - 2. inhibits topoisomerase II enzyme, preventing the relaxing of supercoiled DNA and thus blocking DNA transcription and replication,
 - 3. Creates iron-mediated free oxygen radicals that damage the DNA and cell membranes.

- Patients treated with doxorubicin have been described in acute and chronic cardiovascular effects. The first, which can develop within a few minutes after administration and include hypotension and rhythm disturbances are usually reversible and easily treatable. However, doxorubicin is also able to induce chronic myocardial damage, depending on the cumulative dose of drug administered and clinically characterized by hypotension, tachycardia, ventricular dilation and congestive heart failure. It has been calculated that, from 27 to 60% of patients who undergo this event by doxorubicin die because of it.

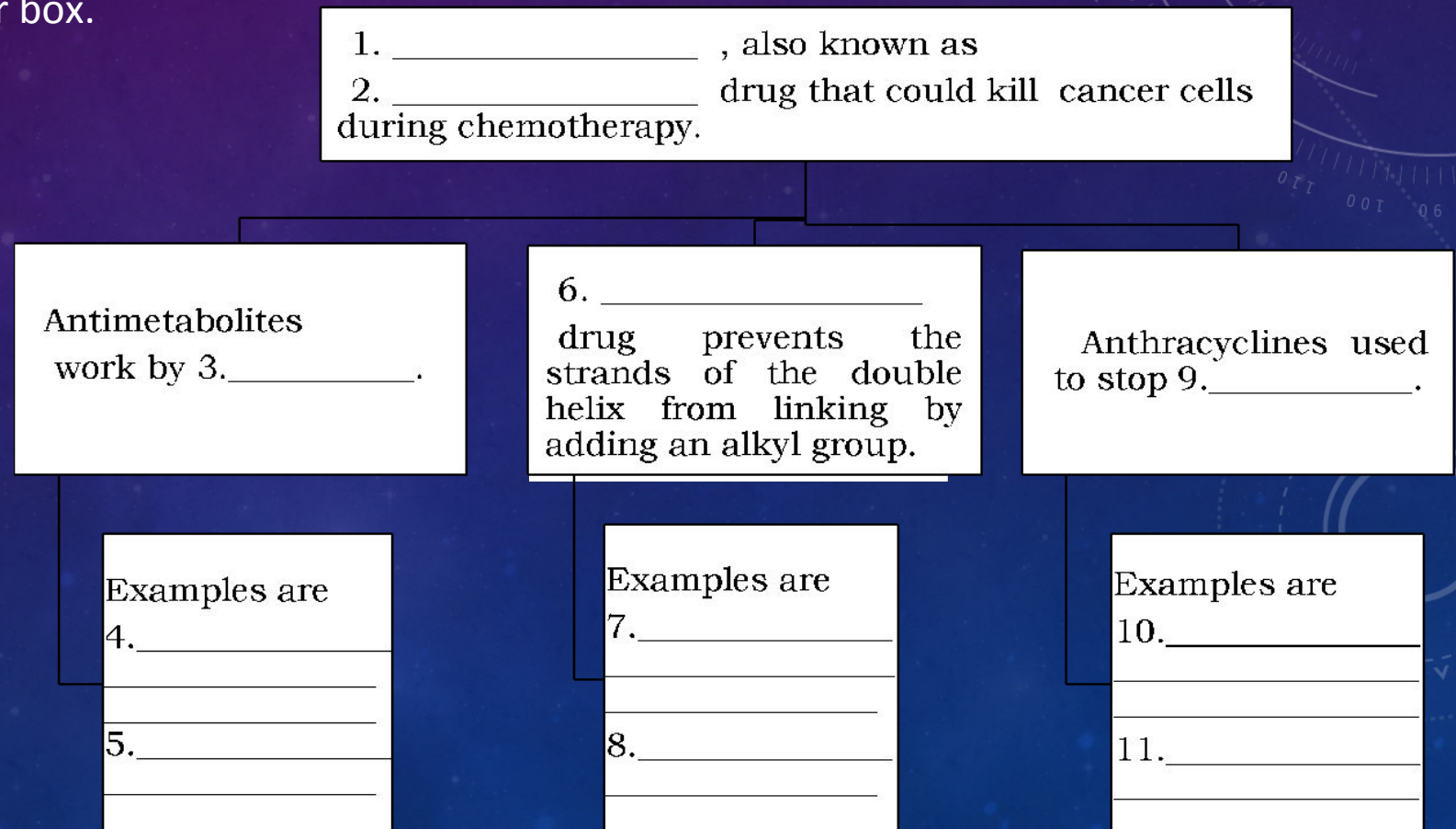
SOME COMMON CHEMOTHERAPY DRUGS:

- ● Doxorubicin (Adriamycin) is one of the most powerful chemotherapy drugs ever invented. It can kill cancer cells at every point in their life cycle, and it's used to treat a wide variety of cancers. Unfortunately, the drug can also damage heart cells, so a patient can't take it indefinitely.
- ● Cyclophosphamide (Cytotoxan) is a drug that can treat many different cancers. Like many other chemotherapy drugs, it scrambles the DNA of cancer cells. Because it damages healthy DNA too, it can also cause long-term injury to the bone marrow, which, in a few rare cases, can lead to a new case of leukemia (cancer of certain white blood cells).
- ● Paclitaxel (Taxol) is an effective drug used for treating some cases of breast cancer and ovarian cancer, but it can damage nerves over time, leaving some people with decreased sensation in their hands and feet. The anticancer compound in this drug was first discovered in the bark of Pacific yew trees.

- ● Fluorouracil (Adrucil) was first approved as a chemotherapy drug in 1962 and is one of the oldest chemotherapy drugs still prescribed today. It's primarily used to treat gastrointestinal cancers (including colon, rectal, stomach) and certain types of breast cancer.
- ● Gemcitabine (Gemzar) is a relatively new chemotherapy drug that is effective at slowing the growth of several types of cancer. Used alone, it's a first-line treatment for pancreatic cancer that has spread or is inoperable. It's also used in combination to treat certain types of breast, ovarian, and lung cancers.

WHAT'S MORE

- Directions: Complete the concept map below by writing terms and definitions to satisfy the idea inside the box and relationship to another box.



WHAT I CAN DO

- Chemotherapy drugs have side effects and some have even more serious effects. It is important to keep track of any side-effects while treating cancer. This worksheet will help a cancer patient to monitor and observe the side effects of his medications. Choose 1 of the 4 options to accomplish this worksheet.
- Options:
 1. By a vlog or blog, using any online social media platform, search for a cancer sur-vive who has shared his battles against his illness via his blogs.
 2. By an interview to a patient in the community, look for a relative or an acquaintance that has undergone chemotherapy.
 3. By an interview with the relative of a patient, look for a person who became a companion to a cancer patient that has undergone chemotherapy.
 4. By an interview to medical personnel in the rural health unit of the barangay.
- PRECAUTION:
 - The teacher should consider the safety of the locality. Activities could be modified and be used with professional judgment.
- Name of cancer survivor/ patient (optional) : _____
- Type of Cancer : _____

