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**QUESTION NO 01**

**EXPLAIN THE LAW OF BERGONIE AND TRIBONDEAU CONCERING RADIO SENSITIVITY AND PHYSICAL FACTOR AFFECTING RADIO SENSITIVITY.**

**ANSWER**

**OVERVIEW:**

In 1906, two French scientists or radiobiologists named Bergonie and Tribondeau tried to make or establish a linkage between the radio-sensitivity and the proliferation of cells. They tried this after noticing the effect of radio-sensitivity on various type of cells.

After establishing this linkage, they introduced that as a law, which is now widely known as “LAW OF BERGONIE AND TERIBONDEAU”.

**DEFINITION:**

According to the law, the radio-sensitivity of a biological tissue or cell is directly proportional to the divisional or reproductive activity of the cell and is inversely proportional to the degree of the differentiation of its law.

**EXPERIMENT:**

The experiment was performed by the testicles of a rabbit. Exposing the testicles to the radiations which causes ionization. The purpose of experiment was only to observe or see the effects appears on the testicles. After conducting such type of experiment, a linkage between the radio-sensitivity and the metabolic state was established by these two French radiobiologists.

**EXPLANATION:**

According to the law, cells which are in reproductive phase and does mitotic activity, they are at higher risk of to be affected by the radiations. In other words, they are highly radio-sensitive.

Those cells which are reproducing themselves and are in active in their mitotic activity will be most harmed by the exposure to the radiation as compared to the mature cells.

The mature cells are less harmed by any radiation exposure because they are no more in developing stage and can properly perform their function. So, that’s why they are kind of radio-resistant.

**Sensitivity According on Cell Cycle:**

We know we have four stages or phases in a cell cycle. Listed below:

1. Mitotic Phase. (M Phase)
2. Preparation for DNA synthesis. (G1 Phase)
3. DNA Synthesis. (S Phase)
4. Post DNA Synthesis/Pre Mitosis Phase. (G2 Phase)

In M Phase, the cells are most sensitive to radiation.

In G1 Phase, the cells are less sensitive to radiation.

In S Phase, the cells are least sensitive to radiation.

In G2 Phase, the cells are most sensitive to radiation.

**Radio-Sensitivity on the Base of Cells Conditions:**

1. Cells of High Metabolic Rate.
2. Well Nourished Cells.
3. Cells of High Division Rate.
4. Non-Specialized type of cells.
5. High proliferative cells.
6. Younger cells.

**Radio-Sensitive Cells:**

1. Lymphoid Tissues.
2. Basal Cells.
3. Hematopoietic Tissues.
4. GI tract Epithelium.
5. Germinal Cells.

**Radio-Resistive Cells:**

1. Liver.
2. Bone.
3. Muscle.
4. Nervous Tissues.
5. Kidney.
6. Cartilage.
7. Mature cells.

**Pregnancy and Others:**

Children are likely radio-sensitive than the adults because they will be in growing stage.

Similarly, Fetus is more radio-sensitive than the children and the same rule is applied to the embryo, which is very most sensitive towards radiation than the fetus.

**Infertility:**

Gonads whether it is female or male, both have high radio-sensitivity and can cause infertility.

**Male:**

Permanent infertility can be done by 6 Gy.

Temporary infertility can be done by 2.5 Gy.

**Female:**

Permanent infertility can be done by 5 Gy.

Temporary infertility can be done by 1.5 Gy.

**PHYSICAL FACTOR AFFECTING THE RADIO-SENSITIVITY:**

The below are the physical factors that affect the radio-sensitivity.

1. **Dose Rate:**

That is the total amount of energy which is deposited per unit mass. If we talk about the controlled conditions, then even in the controlled conditions the response maybe different to exposure.

1. **Linear Energy Transfer (LET):**

It is the measure of the rate by which the total amount of energy is transferred to the mass or tissues.

It is expressed in KeV, energy delivered or transferred per micron to the tissues.

The Linear Energy Transfer of diagnostic X-rays is: 3keV/μ μm.

1. **Relative Biological Effectiveness:**

It is the ratio of biological response of one type of radiation which cause ionization to another, if both are given the same amount of energy.

RBE = $\frac{Dose of standard radiation for producing a required effect}{Dose of test radiation for producing a required effect}$

1. **Fractionation:**

Dividing a dose into a series of small doses or fractions.

A dose fractionation can cause less effect due to the recovery and the intracellular repair between each dose.

1. **Protraction:**

It is the method of administering a dose of radiations over a period of time.

A dose which is delivered over a period of time is less effective than the dose which is given or quickly.

The exact amount dose given to the patient but with a slow rate. It is said to be protracted.

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**QUESTION NO 02**

**SHORT NOTE ON THE FOLLOWING.**

**ANSWER**

1. **EFFECTS OF IRRADIATION OF MACROMOLECULES:**

Radiation induces some major effects or chemical changes in macromolecules which starts from point and leads to an injury.

The consideration that which of the chemical changes occurs by the radiation in a macromolecule are of biological significance that are discussed by the BACQ and ALEXANDER in 1961.

**EFFECTS ON IRRADIATION:**

The following are the major changes or effects which can be occurred after a macromolecules is get irradiated by radiations.

1. **MAIN CHAIN SCISSION:**

This is the process in which the backbone of the macromolecules breaks at random sites or points. The breakage in the back bone reduces the size of the molecule and as well as decreases the viscosity of the solution. The degree of the main chain scission can be determined by measuring the viscosity.

It mostly caused by the heat and ionizing radiation.

1. **CROSS LINKING:**

Macro-molecules have a spur like side structure which extends from the main chain.

A sticky substance is present on the very end of this side structure.

Now when the side spur like side structure get attaches with another macromolecule structure or with the same molecule, this process is known as Cross Linking.

An increase in the viscosity occurs in the cross linking.

Production of large network of linked molecules which are soluble.

The cross linking occurs by the chemical reactions which are started or initiated by radiation, heat, changing PH or pressure.

1. **POINT LESION:**

The breakage or disruption in a single chemical bond of macro-molecule due to the radiation is known is point lesion.

It can lead stochastic effect. One of the cause is the ionizing radiations.

1. **RADIOLYSIS OF WATER:**

**Definition:**

Water radiolysis is the splitting or decomposition of H2O molecules due to the exposure of ionizing radiations.

**Resultant Products:**

The resultant products of radiolysis of water are OH radicals, H atoms, H3O+ ions and molecules like Hydrogen Peroxide (H2O2) and Dihydrogen.

Beside of radiolysis, electrolysis is another pathway by which we can produce the Di-Hydrogen product.

Water Radiolysis can occurs in the following situations:

* 1. Sewage Treatments.
	2. Radiotherapy.
	3. Food Irradiation.
	4. Radio-Sterilization.

**Mechanism:**

The mechanism of water radiolysis is now well understood both theoretically and experimentally.

The water molecule splits into molecules, generally when the molecules rejoins there will be no such damage but when they fails to rejoins, then they may attaches to other molecules forming another product.

The equation for water radiolysis can be written as:

H20 H2O2, HO\*, H\*, H3O+, HO2\*, HO-, H2, eaq-

**Stages:**

This radiolysis occur in three different stages.

* 1. Physical Stage.
	2. Physio-Chemical Stage.
	3. Chemical Stage.
1. **EFFECT OF RADIATIONS ON CELL:**

Radiation effect can either be direct on the cell or indirect. Most of the notable damage or effect on the cell DNA. Yeah we know that the cells have a mechanism by which they can repair themselves. But that mechanism is not that much perfect to overcome the extreme level of irradiations.

Effect of radiations can cause any delay in the metabolic activity of cell, cell death and the development of cancer cells in the body when the person get much amount of ionizing radiation sufficient for causing cancer or cell death.

The radiations can cause the death of the radio-sensitive cells.

* Rapid division or uncontrolled proliferation of the cells leads to malignant tumors.
* DNA damage which cannot be observed normally can also cause a damage to the body or cells.
* Germ cells are also present in the human body. Any effect or damage to the germ cell DNA can cause genetic effect.
* The damage can occurs also when a base is hits by the radiations. And can change or damage the triplet code of the DNA.
* The radiations can also effects the structural make of DNA.
* Genetic mutation can also occurs when there is change occurs by the radiation hit in sequence of codons.

**Direct Radiation Damage:**

Talking about the direct effect or damage to the cell, when the DNA is directly hit by the radiations and causes the damage. Now when the DNA is hit by the radiation directly, it makes the molecules more reactive. It causes **mutation** in the cell or interfere with the **ability of the DNA of making protein**.

Radiation can also cause the **breakage the double stranded DNA**, where the DNA structure is broken.

**In-Direct Radiation Damage:**

In in-direct effect or damage, the ionizing radiation hits the organic molecules and the water present in the cell cytoplasm. And after getting hit by the ionizing radiations, causing the generation of free radicals.

Now the free radicles made can interact with the DNA molecule and can do change the structure of DNA. Making the DNA unable to make protein and do other functions which usually it do.

Here is the thing, cell is also capable of repairing its DNA. There are proteins in the cell, which can detects the effect of radiations or damage and can do repairs in the DNA molecule.

Note that, not all damages made are detected and repaired. And because of that the damage Persists and leads to mutation in the cell. And as the cells divided, the mutation are get transferred automatically to daughter cells.

1. **FRACTIONATION & PROTACTION:**

If a given amount of dose is given over a long period of time, it will not cause the same effect if it was given quickly.

Now here is another thing, if we lengthens the time for a dose to give to a patient. Then we will have to give him a higher dose in order to produce the effect we want.

* **FRACTIONATION:**

Dividing a dose into a series of small doses or fractions is known as fractionation.

A dose fractionation can cause less effect due to the recovery and the intracellular repair between each dose.

**Example:**

When a rat if given a 12 Gy of dose at the same rate that is 3 Gy/minute, the rat will die from the given dose. But if the total of 12 Gy of dose is given in 12 fractions, each of which will be of 1 Gy/min. The rat will survive.

* **PROTRACTION:**

It is the method of administering a dose of radiations over a period of time.

The exact amount dose given to the patient but with a slow rate. It is said to be protracted.

A dose which is delivered over a period of time is less effective than the dose which is given or administered quickly.

**Example:**

If total 10 mSv of dose is given to a patient in one examination, then it will cause cancer, but if the 10 mSv of dose is given over 12 months of period. There will be no cancerous cells generation.

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**QUESTION NO 03**

**SUMMARY OF EARLY EFFECTS OF RADIATION ON THE HUMAN BODY.**

**ANSWER**

Radiations are useful for the medical diagnosis and also for the therapy. But if we take a look on its second side, radiation also plays a role in generating mutation and cancer like diseases, which can lead to death.

**In order to produce a response in the cells of human body, we must have to give a considerable amount of dose to the patient, such a response will be called Early Effects of Radiations.**

Early effect or radiation responses are described as deterministic effects.

**Deterministic Effects:**

They are responses or effects are appears on the human body in days to month. They are also called non-stochastic effects.

These effect totally depends upon the dose rate, amount of dose, LET, REB, Fractionation and the type of radiations.

There is a specific threshold for the effects to occur. If the person is given a dose below that threshold then the effects or response won't appears on the person. Those threshold depends upon the person. And once the exact threshold of the dose exceeds, the severity of the response or effect get increases with the increasing dose.

**Acute Radiation Syndrome:**

This syndrome is the collection of several health problem which are caused by the exposure of high amount of radiations, within days or weeks.

This is also called Radiation Sickness / Radiation Poisoning.

It includes the following:

* Hematologic Death.
* Gastro-Intestinal (GI) Tract Death.
* Nervous System (CNS) Death.

 Beside of the above three lethal syndromes, we have two more listed below which are also associated with acute radiation syndrome.

1. Latent Period.
2. Prodromal period.

**Prodromal Period:**

It’s a period in which the signs and symptoms of the exposure to the radiations appears within minutes to hours by giving a dose of approximately 100 rad. The signs and symptoms may last till a couple of days

The signs and symptoms includes the following:

* Vomiting.
* Fatigue.
* Diarrhea.
* Anorexia.
* Leukopenia.
* Nausea.

**Latent Period:**

Once the initial radiations period in which the person or patients feels sickness finishes, a second period starts which is a state of “comfortable or healthy” occurs, this period is called the latent period.

**Time:**

This time period extends from the hours to weeks.

**EARLY EFFECTS:**

The following are the early effects of radiations on the human body.

1. **Hair Loss:**

Loss of hair occurs with the exposure of radiation. If a person exposes to a radiation continuously, his hairs will fall off quickly and clumps will occur at 200 rem or above exposure of radiations.

1. **Sterility:**

As the reproductive cell proliferate or divide quickly and continuously. Therefore this area can be damage even with a low radiation exposure. This area can be damage by the exposure of even below 200 rem. And if the exposure persists, the person can become sterile.

1. **Skin Erythema:**

The most common effect which is notable in a person after exposure is the skin damage. The skin erythema can occur after the exposure of above 200 rad dose.

The area of the area will look like as Sun Burn. The intensity of the erythema increases with the dose.

1. **Cataract:**

Eye is one of the radio-sensitive portion in the human body. Any exposure of radiations can cause the development of cataracts.

1. **Thyroid:**

Thyroid is one of them, who can be affected by the exposure to different types of radiations.

As thyroid have radio-active iodine. By giving it a sufficient dose of exposure, the radioactive iodine can damage or destroy the parts of thyroid.

1. **GI Tract:**

Once the intestinal tract lining gets exposure of radiations, the patient will face the following problems

* Nausea.
* Blood Vomiting.
* Diarrhea.

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