Genetic Hazards of Radiation

The energy in certain forms of radiation can damage living tissues; although the destruction occurs largely at the cellular level, the damage from severe exposure may be plainly visible, taking the form of burns and various types of organ failure. Although harm can occur to an exposed individual, genetic damage from radiation for subsequent generations is minimal for human beings.

Types of Radiation

Many forms of radiation, such as sound waves and visible light, lack the energy necessary to cause cell damage. However, X-rays, short-wave ultraviolet and the products of radioactive decay are called ionizing radiation because their energy is sufficient to remove electrons from atoms. It is these forms of radiation that are particularly hazardous to human health.

Radiation Levels

Small amounts of ionizing radiation from rocks and minerals and the sky are always present; this is called background radiation and life has long since evolved ways to cope with it. When radiation become significantly greater than background levels, the damage can overwhelm a cell's natural defenses, leading to somatic and genetic damage.

How Radiation Damages Tissue

When ionizing radiation strikes the atoms in a substance, some of its molecules may break apart or become stuck together in the wrong places. Proteins and other biological molecules may have many thousands of atoms arranged in complex structures; damage to them can result in the breakdown of a cell's normal functions.

Somatic Damage

An individual suffers somatic radiation damage when significant amounts of tissue are affected. According to Jefferson Laboratory, a short-term dose of 200 to 300 rads can result in sunburn-like injuries to the skin with accompanying hair loss. At doses over 1,000 rads, the gastrointestinal system suffers upset, including nausea, electrolyte imbalance and other symptoms. In excess of 5,000 rads, the nervous system undergoes shock, leading to confusion, loss of coordination or coma due to internal bleeding and pressure in the brain. Delayed, longer-term somatic effects include the possible development of tumors, cancer and cataracts.

Genetic Damage

Although ionizing radiation can damage DNA, genetic abnormalities are not passed on to the next generation for human beings at any significant rate. According to Princeton University,

only a few radiation-caused genetic disorders are believed to occur per million live births. However, if a pregnant woman is exposed to radiation, the developing tissues in the fetus are vulnerable, particularly in the brain and nervous system; exposure may lead to mental retardation and other serious conditions. For this reason, the Food and Drug Administration recommends limiting medical X-rays and nuclear medicines for pregnant women.

The illustrations;

Humans encounter background radiation every day. Most of the radiation people get exposed to does not occur in high enough concentrations to cause any ill effects. If the background radiation rises above acceptable levels, the affected area experiences higher incidents of certain diseases. Certain building materials expose the residents to higher levels of background radiation than others.

Effects of Radiation

Radiation can damage or kill cells. Radiation also causes mutations to a person's genetic code. The repair systems of the human body repair most of the cellular damage. The body replaces dead cells killed by radiation exposure through the same biological processes that it uses to replace other cells. Exposure to high levels of radiation causes a condition known as radiation sickness.

Safe Levels of Exposure

The Nuclear Regulatory Commission does not let its licensees expose the public to more than 100 millirems of background radiation. Humans suffer few ill effects when the background radiation remains within these levels.

Building Materials and Background Radiation

Buildings made from brick and stone give off more background radiation than buildings made from wood. The granite of the United States Capitol building gives off higher levels of background radiation than homes made of brick or stone, according to the Nuclear Regulatory Commission website.

Ionizing radiation causes many forms of cancer. This type of radiation causes leukemia and cancers of the breast, bladder, lung, esophagus, stomach, multiple myeloma and ovarian cancers. A link may also exist between ionizing radiation and cancers of the pancreas, sinuses and larynx. People respond differently to the same levels of radiation. Even exposure to safe levels of radiation may increase a person's risk of developing cancer.

Maximum Work Environment Exposure; The Nuclear Regulatory Commission set the maximum exposure in a work environment at 5,000 millirems per year. Firefighters who battled the blaze after the nuclear disaster at Chernobyl received up to 80,000 millirems. Twenty-eight firefighters died within three days after the disaster due to acute radiation syndrome.

While radiation can refer to all forms of electromagnetic radiation, including light and radio waves, it's more often used when describing ionizing radiation--high-energy radiation that can ionize atoms, such as the radiation released by the decay of radioactive isotopes. X-rays, gamma rays, and alpha and beta particles are all forms of ionizing radiation. If present at sufficient levels, they can damage the health of humans and other animals.

Types

The energy of a photon of electromagnetic relation is given by the Planck-Einstein equation, E = hv, where E is energy, h is Planck's constant and v is the frequency. From this equation, we know that the higher the frequency, the higher the energy.

Gamma rays and X-rays are at the top of the frequency spectrum and hence have high energy. When a photon of gamma or X-ray radiation strikes an electron or particle, it imparts its energy to its target. This transfer of energy can potentially remove electrons from atoms, or ionize them, and break chemical bonds between atoms.

Alpha and beta radiation are high-energy particles ejected by the decaying nuclei of unstable isotopes. They have an even greater ability to ionize atoms and disrupt chemical bonds, although they are more easily blocked than X-rays and gamma rays. Polonium 210 is one radioactive isotope that emits alpha particles; it made headlines in 2006 when former Russian KGB officer Alexander Litvinenko was poisoned with polonium.

Significance

When ionizing radiation strikes an animal cell, it can break chemical bonds inside molecules or form new bonds. The degree to which these changes harm the cell depends on which molecules are altered and the nature of these alterations. DNA damage is especially deleterious, since accumulated changes to cellular DNA can potentially lead to cancer.

Cells have internal repair mechanisms that can handle damage up to a certain point. However, if enough ionizing radiation strikes an animal cell or the damage is serious enough, the cell will die.

Size

Doses of radiation are generally measured using a unit called the gray or Gy, although a unit called the rad was preferred until quite recently and is still in fairly common use. A rad is equivalent to one centigray. Larger doses are potentially more lethal to animals. An acute

dose of radiation is one rad or above; chronic exposure is repeated exposure to low doses over a long period of time.

Some animals seem hardier than others. A 2008 episode of the Discovery Channel program "Mythbusters" noted that, although cockroaches and flour beetles can tolerate higher levels of radiation than humans, these insects also will die when exposed to massive doses.

Effects

Animal cells that divide rapidly suffer the most serious damage during acute exposure. Cells in bone marrow and lymphatic tissue, for example, are especially vulnerable, as are the fast-dividing cells in the lining of the mammalian gastrointestinal tract. Massive doses of radiation can cause diarrhea, vomiting, internal bleeding, anemia, exhaustion, permanent sterilization and death.

Exposure to high levels can also cause permanent damage to cellular DNA that could potentially result in cancer. The effects in mice have perhaps been studied most extensively, since mice were used in many experiments with radiation.

Benefits

Ironically, some of the same properties that make ionizing radiation a potential hazard have made them useful in veterinary medicine. X-rays are a useful diagnostic tool since they can penetrate soft tissue quite readily but are absorbed by bones, which have a higher electron density.

X-rays can help vets find bone fractures and bladder stones and diagnose other disorders. The level of radiation used in a diagnostic X-ray is low enough that the risks are negligible. Just as in humans, radiotherapy is often used to treat cancer in dogs and cats. Beams of ionizing radiation are focused on the tumor in an effort to kill the cancer cells and shrink the tumor. Side effects typically include skin problems that may encourage the animal to scratch. While fatigue and nausea are possible side effects of radiotherapy in humans, these are unusual in cats and dogs.

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Splitting an atom, or nuclear fission, has resulted in incidents where dangerous radiation was released, and these events have become bywords for destruction and disaster: Hiroshima and Nagasaki, Three Mile Island, Chernobyl and, most recently, Fukushima. The technology to release energy by splitting heavy elements such as uranium and plutonium was developed over the last century. The energy produced by nuclear fission can be harnessed, but also represents the greatest source of risk associated with splitting an atom.

Radiation Released by Fission; When an atom is split, three types of radiation that can damage living tissues are released. Alpha particles are made up of protons and neutrons and cannot penetrate human skin, but do damage if released inside a body. Beta particles are electrons that move very quickly and can penetrate the skin, but will be stopped by wood or metal. Gamma rays are high-energy beams that can penetrate bodies and require significant protective shielding. All types of radiation damage living tissues through a process called ionization. Ionization is the transfer of energy to the molecules that make up tissue, breaking chemical bonds and causing damage to cells and to DNA.

Short- and Long-Term Risks of Radiation Exposure

Short-term exposure to high levels of radiation results in acute radiation poisoning. Symptoms include vomiting, hair loss, skin burns, organ failure and even death. Most exposure to radiation isn't acute and the risks of low-level long-term radiation exposure are called stochastic health effects. "Stochastic" refers to probability, in this case the increased probability of certain health problems. Stochastic health effects include an increased risk of cancer and of passing genetic mutations on to offspring. At three times the normal lifetime dose of radiation, it is estimated that five or six people out of 10,000 would get cancer.

Uncontrolled Fission Reactions

During nuclear fission in a nuclear reactor, one atom splits and releases neutrons, which initiate the same process in nearby atoms. In nuclear reactors, this process is carefully controlled, but during a nuclear reactor meltdown or the detonation of an atomic bomb, it can grow exponentially until many nuclei are releasing energy at once. Uncontrolled reactions generate heat, force and radiation on a regional scale. Because of the potential risk, nuclear power plants have safety plans and containment systems, and are hardened against terrorist attacks.

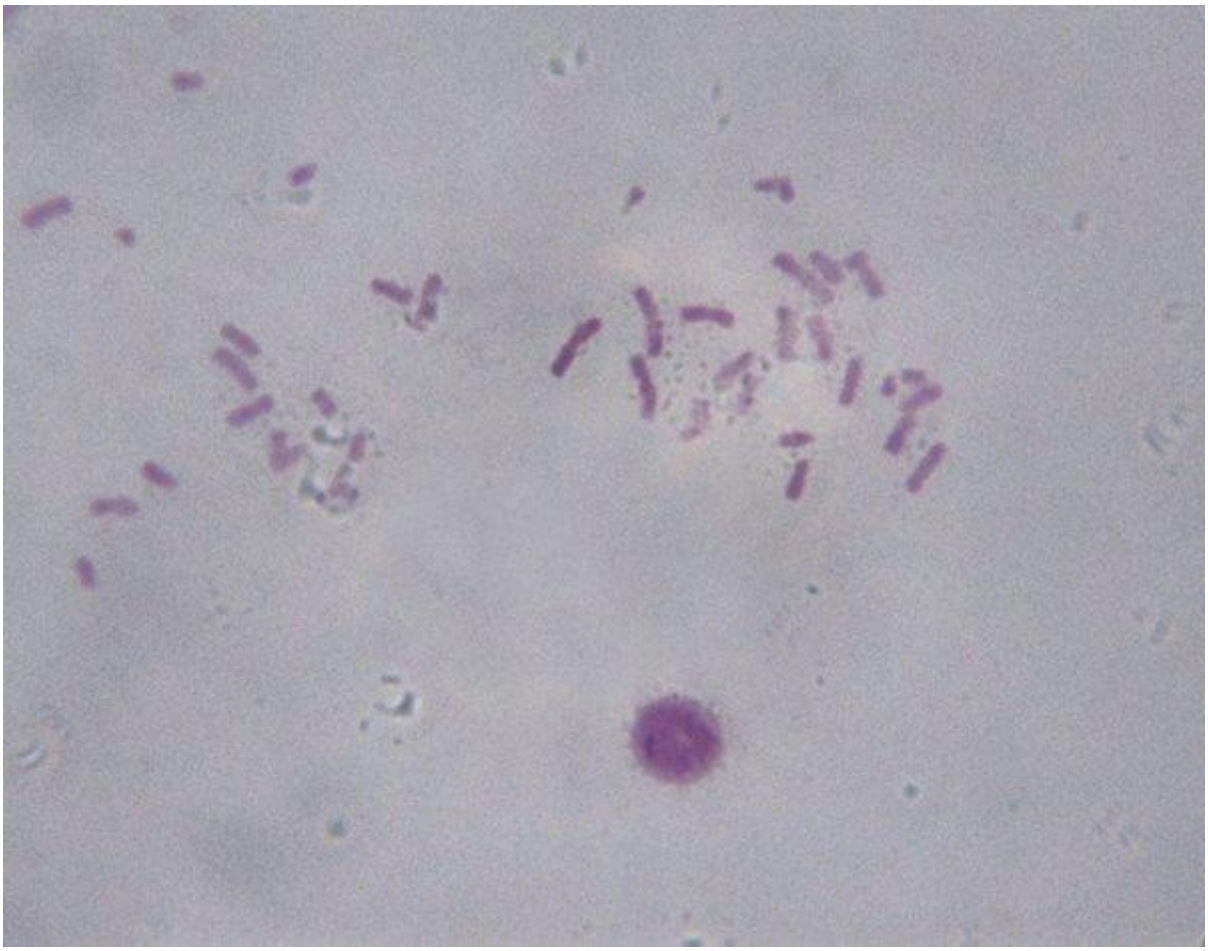
Radioactive Waste

Rods of uranium and plutonium are used in a nuclear reactor, but the atoms in the rods get used up until only a few are left. Once they have exhausted most of their supply of atoms for fission they are considered waste. These waste rods are still a risk, however, because they continue to react at a much slower rate and emit radiation. Disposing of radioactive waste creates a risk for the surrounding area. It is estimated that the spent fuel rod waste for one nuclear power plant will result in one death for every 50 years of operation.

Defects can come from two sources: genetic heredity from your parents, and environmental exposure to drugs, chemicals, radiation, biological organisms and heat, as well as poor nutrition. Both hereditary and environmentally-caused defects are usually apparent at birth. It is during development of a child that exposure to harmful

environmental agents will have the greatest effect. During growth in the womb, the combination of the parents' genetic material will also express any hereditary defects.

these are the Parents' Genes



The units of heredity are genes, composed of deoxyribonucleic acid -- DNA -- and organized onto structural support units known as chromosomes. A child inherits a single copy of genes from each parent and needs two copies of each gene for normal development. Inherited defects can come from abnormalities in genes and the number of genes as well as the number of chromosomes, such as extra, missing, broken, deformed, or joined-together chromosomes. Often, hereditary defects are the result of complex interactions between genes, as well as between genes and environment factors, as is the case with poor nutrition.

1. Pregnant women carry a developing child from fertilization to birth. During this time, infections by bacteria, viruses, fungi, and protozoans can cause birth defects and malformations of the child. Infection of a pregnant woman with German measles, or rubella, can cause defects to a newborn's eyes, ears and heart. Women infected with toxoplasmosis -- Toxoplasma gondii -- can pass the infection to the baby, causing a malformed child. The likely sources of this infection are from eating uncooked or undercooked meat and from gardening.

Chemicals, drugs and alcohol are common causes of birth defects. For example, a sedative used to calm pregnant women in the 1950s and 60s was determined to be the cause of phocomelia, a defect resulting in short limbs. Fetal alcohol syndrome is caused when fetuses are exposed to large quantities of alcohol, resulting in decreased mental ability and growth of the baby. Babies exposed to the chemicals from smoking during development are often born with lower-than-average weight and are at greater-than-normal risk for birth defects.

Heat, Radiation and Poor Nutrition

Radiation can cause damage to cells and the DNA of all individuals exposed, but a developing fetus is particularly at risk. The resulting damage to cells and the DNA will likely be expressed as a defect. Exposure to high temperatures has been linked to an increased risk of a rare form of fetal blindness. Proper nutrition of the mother before and during pregnancy is vital to normal development of the child. Low amounts of the B vitamins can cause defects in the spine and brain, as well as the heart.

2. When a cell divides, it creates two identical daughter cells that each carry a copy of the original cell's DNA. The name for this process is mitosis, and errors in the process result in incorrect DNA copies. The effects of these errors on the health of the organism range from benign to deadly, depending on their number errors and type. One potential consequence is cancer; scientists trace all cancer types back to harmful mutations multiplied by mitosis.

Mitosis and Cancer

DNA, sometimes called a genetic blueprint, contains the hereditary material in nearly all organisms. The improper copying of DNA produces two types of errors, or mutations. Silent mutations have no impact on the DNA sequence, but missense mutations, which alter amino acid sequences, often impact the associated function. Missense mutations can multiply over time, leading to cell cycle disruption and the formation of tumors , which are the product of runaway cell reproduction. Cancer occurs when mutated cells ignore or override the normal "checkpoints" regulating mitosis and begin to reproduce uncontrollably.

The process of mitosis generates identical daughter cells by arranging chromosomes into two equal groups. When the process occurs normally, chromosomes attach to string-like spindles and begin to move to the middle of each daughter cell. If chromosomes fail to attach to these spindles, however, a daughter cell might have an extra copy of a chromosome after the cell divides, or it might be missing one. Scientists refer to the condition whereby cells have an incorrect number of chromosome as aneuploidy. Down syndrome, which is characterized by specific facial features and higher susceptibility to

certain diseases like Alzheimer's and leukemia, is one disorder caused by the presence of an extra chromosome.

Effects on Organelles; Supersession of the mitotic checkpoints in cancer cells causes runaway damage to the cell's organelles, which are units within the cells that carry out specific functions. During normal mitosis, damaged organelles have a chance to repair and recover between cell divisions, but they don't have this opportunity when cell division doesn't stop. Cells with damaged organelles can die. According to a 2012 study, leakage from damaged mitochondria, which are organelles that provide energy to the cell, can trigger the release of "executioner" enzymes.

Mosaicism

Cell mutations within an individual aren't always uniform; some cells may have a mutant version of a gene while others have the normal version of the same gene. Geneticists refer to this condition as mosaicism. In somatic cells, or cells other than egg or sperm cells, the individual may not be affected by the mutations, but if the mutant genotype is widespread and harmful enough, the mutation can have a major impact. Two examples of diseases linked to mosaicism are hemophilia, a blood-clotting disorder, and Marfan syndrome, which produces unusually long limbs.

The genetic material of eukaryotic cells is coiled tightly in linear bundles called chromosomes. Genetic alterations are either inherited from a parent, or they occur de novo, meaning a new variant appears during reproductive cell formation or in embryonic development.

Chromosomal abnormalities can also occur in non-reproductive cells at any stage of life.

Chromosomes segregate during asexual mitosis and in sexual reproductive processes like meiosis. Chromosomes condense when the cell divides to keep the strands of DNA from tangling, breaking or partially separating.

Each organism has a specific amount of chromosomes, often coming in homologous pairs. Including sex chromosomes (X and Y chromosomes), humans have a total of 46 chromosomes: one pair of 23 chromosomes inherited from the mother and the other pair of 23 from the father. Dogs have 39 pairs of chromosomes, a rice plant has 12 pairs and fruit flies have four pairs.

Chromosomal Abnormalities

Chromosomal abnormalities are changes to the number or structure of chromosomes that can lead to birth defects or other health disorders. Slight alterations to genes on the chromosomes may produce new traits such as bigger claws that may be beneficial to survival. However, they can also have detrimental effects.

Chromosomal abnormalities in the fertilized egg can halt cell growth and trigger spontaneous abortion.

Causes of Chromosomal Abnormalities

The cause of chromosomal abnormalities is usually attributable to accidents during DNA replication or cell division. Normally, any problems are corrected by enzymes at checkpoints, or the dividing cell is not allowed to proceed to the next phase of the cell cycle.

If mistakes are not noticed or fixed, chromosomal abnormalities can cause cell death, or the abnormalities can be passed along to offspring with potentially dire consequences.

Numerical Chromosomal Abnormalities

When chromosomes do not segregate properly, cells can end up with missing or extra chromosomes. Chromosomal abnormalities characterized by an atypical number of chromosomes are called aneuploidy.

For instance, trisomy 21 (Down syndrome) is caused by an extra copy of chromosome 21 in the egg or sperm that results in the fertilized egg receiving three copies of chromosome 21. Mosaic trisomy 21 is a rare form of Down syndrome that happens after fertilization.

Trisomy 13 (Patau syndrome) causes severe intellectual and physical disabilities. Trisomy 18 (Edwards syndrome) is even more severe and can threaten children's survival. Trisomy X is an extra copy of the X chromosome in female sex cells. Klinefelter syndrome happens when a male inherits an extra X chromosome from his mother; the XXY condition is sometimes associated with advanced maternal age.

Monosomy occurs when one chromosome is partially or entirely missing. For example, females with Turner syndrome only have one X chromosome instead of two X chromosomes. Cri du chat syndrome results from a deletion of the short arm of chromosome 5.

Structural Chromosomal Abnormalities

Damage or changes to the structure of the chromosomes can also lead to health problems and birth defects. Cell functions may cease when large segments of DNA are missing or added to chromosomes.

Chromosomal abnormalities tests are options offered with some home DNA testing kits. Identifying carrier status for mutated genes can aid in early detection and treatment of chromosomal abnormalities and their syndromes.

Types of structural abnormalities include:

Deletion: A portion of a chromosome is deleted.

Duplication: A portion of a chromosome is doubled or duplicated.

Inversion: Parts of the chromosome are mirrored and swapped.

Translocation: One part of a chromosome is transported to another chromosome, or an entire chromosome attaches to another chromosome (Robertsonian translocation).

Ring chromosome: The ends of chromosomes with broken "arms" attach, forming a ring.

Cancer is a complex genetic disorder exhibiting considerable variability, according to the National Cancer Institute. Inherited or acquired genetic mutations can cause cells to go haywire, turning normal cells into unregulated factories of mass cell production.

Unfettered cell growth upends the natural cell cycle, which can lead to human cancer formation unless tumor suppressor genes intervene.

Tumor suppressor genes are the body's natural army against tumor and cancer progression. Healthy tumor suppressor genes function to regulate cell activity. Mutated or missing tumor suppressor genes increase the risk of tumor formation.

Genes Linked to Human Cancer

The somatic cells of the human body contain thousands of genes normally located on 46 chromosomes. Genetic material in DNA determines hereditary characteristics, including rare genes for cancer. At the molecular level, genes work by synthesizing proteins that control cell differentiation, growth, reproduction and longevity.

Somatic mutations give rise to the production of a new type of protein that can be helpful, inconsequential or harmful to the organism's adaptation and survival.

Cancerous tumors result from adverse gene mutations replicated by the cells. Altered protein sequences send faulty messages to the cell that disrupt normal operations. When mutations occur, normal tumor suppressor genes can sometimes fix the DNA damage of affected cells or flag irreparably damaged cells for destruction.

Mutations to tumor suppressor genes can result in abnormal cell growth and tumor formation. Certain inherited mutations, such as BRCA1 and BRCA2, are linked to a higher risk of breast cancer, for instance. A common mutation in cancerous cells is an absent or impaired p53 gene.

Tumor Suppressor Genes in Cell Division

The nucleus operates as the cell's command center, controlling gene expression and cell division. Rate of cell growth is determined by the organism's age, condition and changing

needs. Proto-oncogenes help cells divide in a normal fashion. Anti-division tumor suppressor genes prevent overgrowth through various strategies.

Oncogenes can cause the cell to grow erratically and out of control. Rapid, unregulated growth of cells is associated with tumor formation. Cancer can also occur when tumor suppression genes are turned off, leaving the body vulnerable to deleterious genetic mutations.

Within the human body, there are approximately 250 oncogenes and 700 tumor suppressor genes that regulate cell functioning, according to a 2015 article in EBioMedicine.

For example, p21CIP is a kinase inhibitor that plays an active role in tumor suppression. Specifically, p21CIP can suppress tumor growth, repair damaged DNA and inhibit cell death from causing tissue damage.

Tumor Suppression Genes and Genetic Mutations

Because cancer is a genetic disease, accumulated mutations throughout life increase the odds of tumor formation. Cancerous tumor cells are a “genetic train wreck” made up of pathogenic cell mutations, gene fusions and abnormal gene expression, as described in EBioMedicine. Tumor suppressor genes can help the cell respond to mutations before dividing and passing on altered DNA.

Protective actions of tumor suppression genes may include:

Inhibiting the division of damaged cells

Repairing mutated/damaged DNA

Eliminating malfunctioning cells

For instance, p53 protein is a tumor suppressor gene – mapped on the 17th chromosome – that encodes for protein involved in cell regulation. It works by binding to a specific region DNA, which stimulates production of the p21 protein, which subsequently inhibits uncontrolled cell division and related tumors.

APC protein made by the APC gene partners with other proteins in the cell to manage cellular functions. APC is considered a tumor suppressor because APC keeps cells from dividing too fast and monitors the number of chromosomes following cell division. Mutations to the APC gene can increase the risk of polyps and colon cancer.

Tumor Suppressor Genes and Cell Death

The human body protects itself by killing off mutated or damaged cells that are potentially harmful. This process is called apoptosis, a type of programmed cell death.

Tumor suppressor proteins act as gatekeepers that put a stop to potential threats. Tumor suppressor gene p53 encodes proteins that tell damaged cells to self-destruct, for instance.

Located on chromosome 18, BCL-2 is a proto-oncogene that maintains a balance between living and dying cells. Subgroups of the protein serve a pro- or anti-apoptotic function. Mutations to the BCL-2 gene can lead to cancers like leukemia and lymphoma.

The Tumor Necrosis Factor (TNF) gene encodes a cytokine protein involved in the regulation of inflammation. TNF plays a part in apoptosis, cell differentiation and autoimmune disorders. TNF in macrophages can kill certain types of cancer cells in tumors.

Tumor Suppressor Genes and Senescence

Cells are finite and eventually enter senescence after repeated cell divisions. Senescence is a period of arrested growth. When cells enter senescence, they stop dividing as a way to stop aged, damaged genetic material from being passed to daughter cells.

If cells that are supposed to be in senescence keep dividing, that can contribute to tumor growth. During senescence, mature cells accumulate and secrete inflammatory chemicals into adjacent tissue, which increases the risk of age-related diseases like cancer.

Discovering drugs to coax malignant cells into senescence and reduce their secretion of inflammatory chemicals may expand options for cancer treatment.

Cyclin-dependent kinases (CDK1, CDK2) are proteins involved in cell growth. CDK inhibitors arrest cell division and have the potential to “become important weapons in the fight against cancer,” according to a 2015 article in Molecular Pharmacology.

CDK inhibitors could play a role in slowing tumors and triggering the demise of cancer cells. However, the variability of tumor DNA makes it difficult to engineer tumor-specific drugs that work for all tumors .

Tumor Suppressor Genes and Angiogenesis

Solid tumors need abundant food and oxygen. Growing tumors start by developing their own blood vessels to supply fuel – a process called angiogenesis. Chemical signals stimulate the production of new blood vessels, thus ensuring a rich supply of nutrients to multiplying tumor cells.

Expanding tumors can then metastasize, or move, to other locations of the body and prove fatal. Promising new drugs are being tested to prevent tumor angiogenesis and starve the tumor, according to the National Cancer Institute. This approach to cancer treatment targets the blood supply instead of the tumor itself.

The PTEN gene activates enzymes that help control cell growth and prevent tumor formation. Other functions include controlling angiogenesis, cell movement and apoptosis.

The p53 protein has been shown to inhibit angiogenesis in tumor formation, but the mechanism is not well-understood.

What Happens to Tumor Suppressor Genes During Cancer?

Tumor suppressor genes do not always win when waging war against cancer. Other mutations could mean the genes are silenced or less active.

When cancer invades the body, tumor suppression genes may be inactivated at the protein level and rendered defenseless. Aggressive cancers may even cause tumor suppressor genes to go extinct from the genome.

Moreover, "good" genes can go rogue. For instance, the job of the retinoblastoma protein (pRB) is to suppress tumors by blocking the growth of abnormal cells. However, mutation in the pRB gene can actually lead to uncontrolled cell growth and higher incidents of tumors.

Knudson's Two-Hit Hypothesis

In 1971, Alfred Knudsen, Jr. published his "two-hit" hypothesis based on studies of inherited and non-inherited cases of childhood retinoblastoma (eye cancer). Knudson observed that tumors only developed when both copies of the RB1 gene in cells were missing or damaged.

He concluded that the mutated gene was recessive, and one healthy gene could act as a tumor suppressor.

Types of Human Cancer

The National Cancer Institute estimates that more than 100 types of cancer occur in humans. The most common type listed are carcinomas – cancers occurring in epithelial cells. Many familiar types of cancer fall in this category:

Glandular tissues: Breast, prostate and colon cancer.

Basal cells: Cancer in the outer layer of skin.

Squamous cells: Cancer deep in the skin; also found in lining of certain organs.

Transitional cells: Cancer in the lining of bladder, kidney and uterus.

Other types of cancer include soft tissue sarcoma, lung cancer, myeloma, melanoma and brain cancer. Li-Fraumeni syndrome is an inherited predisposition to rare cancers caused by a p53 mutation.

Without functioning p53 proteins, patients are at higher risk for multiple types of cancers.

Anticodons are groups of nucleotides that play a crucial role in formation of proteins from genes. There are 61 anticodons that code for protein formation, even though there are 64 possible combinations of anticodons. The additional three anticodons are involved with

termination of protein formation. Genetic mutations occurring within the anticodons can cause severe changes to proteins made from genes, leading to diseases such as cancer.

Nucleotides

Nucleotides are the building blocks of genetic material. DNA and RNA are composed of numerous nucleotides bound together in long strands. DNA is composed of two strands, while RNA is composed of a single strand. The two strands in DNA bind together, because they have a complementary sequence of nucleotides. The nucleotides adenosine and guanine are complementary to thymine and cytosine, respectively.

Protein Translation

Gene expression begins with the DNA being converted into RNA in a process called transcription. The RNA is composed of the complementary nucleotides to the DNA in the gene. This RNA contains codons, which are groups of three nucleotides. The codons are crucial for producing the protein corresponding to the gene, in a process called translation. During translation, molecules known as tRNA, or transfer RNA, bind to the codons in the RNA molecule. Each tRNA contains an anticodon and an amino acid specific to the sequence of the anticodon. During translation, the anticodon of a tRNA binds to the complementary codon on the RNA and the amino acid is transferred from the tRNA molecule to the amino acid from the preceding codon, forming a protein.

Stop Codons

There are 64 possible combinations of three nucleotides thAT can form codons. However, only 61 of these combinations code for amino acids. This is because three codon combinations code for a stop in protein translation. The tRNA molecules with anticodons complementary to the stop codons lack an amino acid. This causes a break, or stop, in the elongating amino acid chain and the formation of the protein halts. All genes contain the nucleotide sequence for a stop codon at the end of the gene.

Genetic Mutations

Several types of genetic mutations can cause the improper formation of proteins from genes. Point mutations are the substitution of a single nucleotide, which creates a different codon and therefore a different amino acid. The incorporation of a different amino acid in the protein can completely disrupt the normal function of the protein. The most damaging type of point mutation, a nonsense mutation, codes for a stop codon in the middle of the gene. This causes formation of the protein to stop prematurely and can even prevent the formation of most of the protein, depending on where the stop occurs. These types of mutations can lead to either a loss of function of the resulting protein or a gain of a completely different function, often causing cancer.

The natural process of copying DNA in human cells is very accurate, but mistakes do happen. Estimates of the mutation rate vary, but a 2011 study found that for every 85 million nucleotides assembled in DNA during human sperm or ova (egg) production, one will be a mistake: a mutation. The statistic concerns mutations in sperm and ova cell production because only mutations in these specific cells are passed on to the next generation.

Mutations are only passed on to offspring when they occur in germ cell DNA, which are the cells that create sperm or ova. The other kind of cells, somatic cells, are the rest of the cells in the body, and mutations that occur in these cells do not get passed on to offspring. For every 85 million nucleotides assembled in DNA during human sperm or ova production, one will be a mutation. Since the humane genome is 6 billion nucleotides long, this still adds up to dozens of mutations per generation, but most are not significant enough to be detectable.

Some mutations are so severe that the embryo or fetus does not make it to term; in this case, the mutation has not been passed on. In other cases, life is viable with the mutation, but quality of life for the offspring suffers. If a germ cell has a mutation in its DNA, the sperm or ova it creates is still unlikely to be passed on to offspring. The mutation will be inherited only if it occurred on a chromosome in either the sperm cell or the ova cell out of many that eventually unite to form a zygote.

Somatic Cells

Human body cells fall into two broad categories: germ cells and somatic cells. Germ cells produce sperm and ova; all the other tissues of the body are somatic cells. A somatic cell mutation in an organism is passed on to daughter cells in the organism. But this type of mutation doesn't affect future generations because only genes carried by sperm or ova can become part of offspring's genetic material. A mutation in a germ cell, by contrast, will not affect the body, but will affect any offspring from the sperm or ova the germ cell creates.

Mutation Rates

Children typically inherit some mutations from their parents. The average mutation rate of 1 in 85 million nucleotides or genetic code letters during sperm or ova production may sound low. However, the human genetic code is 6 billion letters long. This mutation rate adds up to dozens of mutations per generation, although many of these mutations have no detectable effect. In general, scientists think that sperm cell DNA carries more mutations than ova cell DNA because females are born with all of the ova they will ever have, but males make new sperm continuously throughout their lifetimes, allowing for more errors with time.

Lethal Mutations

Sometimes, a mutation is so severe it's lethal; a fetus carrying this type of mutation never reaches full term. Many miscarriages, for example, are caused by serious mutations or chromosomal rearrangements that prevent the fetus from developing normally. In these cases, although a mutation occurred in a germ cell, it is not passed to the offspring because the offspring was not born. In other cases, mutations cause birth defects that while not lethal, are serious and can wreak havoc on the offspring's quality of life.

The process of cell division that makes sperm and ova cells is complicated. It would be incorrect to assume that all mutations that occur in any germ cell will be inherited. The specific sperm or ova cell carrying a mutation has to battle great odds among the large numbers of sperm and ova before it can become part of a new organism. The mutation will be passed on only if it occurred on a chromosome in either the sperm cell or the ova cell that unite to form a zygote.

More than 60 elements have at least one isotope that is radioactive. An isotope is a variant of a particular element whose nucleus has a different number of neutrons. The radioactive elements can be broken down into three classes: primordial, existing before Earth was formed; cosmogenic, formed through cosmic ray interactions; and human-produced elements. All radioactive elements share certain characteristics.

Disintegrates

The nucleus of a radioactive element is unstable. The nucleus will break down over time, reducing the amount of the element remaining. This disintegration occurs naturally and does not need an outside stimulus to occur. All man-made elements are radioactive and break down. The speed at which an element breaks down is called "half-life," or how long it takes for half of the atoms present to disintegrate. This measure can determine how relatively stable or unstable the element is. For example, the half life of uranium is over 4 billion years, while the half life of francium is just over 20 minutes.

Different Elements

As the element disintegrates, the subatomic particles of the nucleus form different elements. These particles are not lost to the environment. For example, uranium disintegrates in a number of steps, becoming different elements along the way. These include thorium, protactinium, radium, radon, polonium, bismuth and lead. The last step in the series, lead, is a stable element that does not disintegrate. These created elements are called daughters of the parent element.

Radiation Emission

Radiation is the energy released from the atom as the element disintegrates from one element to another. There are many types of radiation, including light and microwaves. When radioactive elements release their energy, the radiation is called ionizing radiation,

which includes charged particles. These charged particles are the harmful radiation that is dangerous to living organisms. However, not all radiation emitted from the elements is harmful to humans and are classed as alpha and beta ray radiation.

Detection

A number of tools are used to detect the presence of radioactive materials and elements. A Geiger counter is a well-known device used to measure radiation levels. The device works by creating electrical charges when it encounters radiation emitted from radioactive materials. The more radioactive material, the higher the reading on the device.

Though we are exposed to radiation constantly – in the form of sunlight – and all wavelengths of light can be considered radiation, some forms of radiation are more harmful to humans than others. In the same way that too much sunlight can cause a sunburn or skin cancer, overexposure to X-rays, gamma rays and certain radioactive particles can cause anything from blindness to serious cell damage to death. To prevent this, every person working with, in or around radioactive substances or environments wears a dosimeter – sometimes referred to as a radiation badge, radiation band or TLD detector. These simple devices allow wearers to keep track of the radiation they're absorbing, to prevent them from falling ill and to determine how hazardous a radioactive environment may be.

A radiation dosimeter is a scientific instrument used to measure exposure to ionizing radiation. Commonly worn in the form of a badge or bracelet, these meters contain phosphor crystals capable of trapping electrons freed by harmful ionizing radiation. When heated, the crystals release trapped electrons in the form of light – which can be measured to determine how much radiation the meter and its wearer have been exposed to. Dosimeters are used by researchers, maintenance staff and anyone else working in a potentially radioactive environment.

Common Dosimeter Uses

In contrast to the more familiar Geiger counter, a scientific instrument that measures the amount of radiation present in a given area from moment to moment, the various types of radiation dosimeters are used to track radiation exposure in an area or in a person over a prolonged period of time. Dosimeters can be placed on their own in radioactive environments to track the average amount of radiation given off, but most often they are worn by researchers, maintenance staff and other officials working with or around radiation. The staff of many university departments wear dosimeters, as do staff at nuclear power plants and some hospitals. Chemotherapy patients will often wear dosimeters as well during treatment, to ensure that the amount of radiation they're exposed to stays in the helpful range, rather than entering a potentially deadly one.

Increases Cell Mutations

Because ultraviolet radiation destroys cells, the chances of mutation are great. Affected plants are often small and weak with altered leaf patterns.

Man-made pollutants can threaten human health and compromise the natural ecosystem and environment. Man-made pollution is generally a byproduct of human actions such as consumption, waste disposal, industrial production, transportation and energy generation. Pollutants can enter the surrounding environment in various ways, either through the atmosphere, water systems or soil, and can persist for generations if left untreated.

Air Pollution

Air pollution occurs when harmful chemicals or particulate matter are introduced into the atmosphere. Depending on the type and severity, air pollution can damage human and animal health as well as the natural environment. Major contributors to air pollution are transportation, industry and agriculture, which respectively release large amounts of carbon dioxide, sulfur dioxide and methane (to name a few) into the atmosphere. Furthermore, as air pollution changes the chemical composition of the atmosphere it can lead to systemic changes in climate systems.

Water Pollution

Water pollution occurs as bodies of water (oceans, lakes, rivers, streams, aquifers and atmospheric water) become contaminated by man-made waste substances. Water contamination can have adverse effects on human health (for instance, when drinking water sources are contaminated) and surrounding ecosystems. Pollution of local water systems can occur through individual activities (for example, disposing of consumer detergents down sewer drains), industry or agricultural (such as the runoff of chemical fertilizers).

Soil Pollution

Soil pollution occurs as harmful man-made substances leach into the soil. This can be caused by pesticide run-off, leakage of underground storage tanks, dumping, percolation of contaminated surface water to lower soil strata or the presence of landfills. Soil contamination by man-made pollutants can have devastating consequences to ecosystems as contaminants travel up the food chain from plants to higher-order carnivores. Contamination of soil used for agriculture or in proximity to a public drinking water source can have similarly dire consequences for human health.

Radioactive Pollution

Radioactive pollution can result from the improper disposal of nuclear waste, the accidental discharge of core material from a nuclear power plant or the detonation of a nuclear explosive device. Depending on the type of nuclear material present, radioactive

contamination can last for decades, as each nuclear isotope has its own half-life. Ionizing radiation is destructive to living tissue and can cause chronic illnesses (particularly forms of cancer), mutation and, in large doses, death immediately following exposure.

The thyroid gland synthesizes thyroid hormones, which is used to control various metabolic functions of the body. To make thyroid hormones, the gland needs iodine. As the thyroid is the only part of the body that collects iodine, medical professionals can take advantage of the localized uptake process in medical imaging procedures, using radioactive iodine.

Iodine Isotopes

The regular non-radioactive iodine isotope has an atomic weight of 127. This includes 74 neutron particles and 53 protons. The type of iodine used for most thyroid imaging is iodine 123, which has the same amount of protons but only 70 neutrons. Another radioactive isotope, iodine 131, is also used medically but on a limited basis because it can damage thyroid cells.

Iodine 123 Radioactivity

Any radioactive isotope of an element is constantly breaking down and releasing energy as radioactivity. In the case of iodine 123, gamma radiation is released. Gamma radiation comes from the nucleus of iodine 123 in the form of rays with very small wavelengths and very high energy. The gamma rays can easily pass through the body but do not make any of the tissue radioactive. Radiation from gamma rays can severely damage human tissue and is the primary cause of radiation sickness, but iodine 123 has such a short half-life that tissues are not exposed to excessive gamma rays.

The gamma radiation from the body is picked up by a scanner. The scanner will then show where the iodine 123 is and where it has concentrated. The medical professional can then assess whether the amount of iodine 123 that the thyroid takes up is in the normal range.

Background to the Test

Iodine 123 has to be swallowed in a pill or liquid before the body takes it up and it collects in the thyroid gland. According to the American Thyroid Association, some people have allergies to iodine-containing substances like contrast dyes used in X-ray tests or seafood, but iodine 123 is safe to ingest for these people. On rare occasions, the much more radioactive isotope Idodine 131 can be used in imaging tests, but iodine 123 is used most often. Iodine 131's primary medical application is to destroy diseased thyroid cells. Neither should be used in pregnant or breastfeeding women, though, as the radioactivity can potentially harm the baby.

Chromosomes are found within each cell of the human body. These structures are made primarily of protein, but also contain a molecule of DNA. Each parent donates 23 chromosomes to the offspring; therefore humans have 46 chromosomes total. The sex cells, the female egg and the male sperm, are unlike other cells in the body because they carry only 23 chromosomes, and not 23 pairs of chromosomes. A chromosome is either an X or a Y. When an X chromosome and a Y chromosome combine to form a pair, the resulting sex of the baby is male.

Female vs. Male Sex Chromosomes

The female's eggs contain an X chromosome. However, the male's sperm can contain either an X or a Y chromosome. Therefore, the individual sperm cell that reaches the egg first to fertilize it will determine the sex of the embryo. If two X chromosomes combine, the sex is female. The Y chromosome contains specific DNA that give instructions for the male characteristics and physical features.

Some Diagnostic equipments ; Cloud of electrons

An atomic nucleus is surrounded by a cloud of electrons. Electrons carry a negative charge that is equal and opposite to the charge carried by a proton. To form a neutral atom, the number of electrons has to equal the number of protons in the nucleus.

Practitioners of nuclear medicine utilize small amounts of radioactive isotopes for diagnostic purposes. These isotopes, called radioactive tracers, enter the body by injection or ingestion. They emit a signal, usually gamma rays, that can be identified. The medical provider targets a particular organ or body part. The tracer provides valuable information that assists in making a diagnosis.

Process

Radioactive tracers utilize the positive qualities of radioactivity, the ability to emit a signal, while minimizing the negative effects. Isotopes use elements with a short half-life to reduce the dangers of radioactive exposure to the patient. A half-life represents the amount of time it takes for one-half of a substance's radioactivity to decay. For example, a material with a half-life of six hours will lose half of its radioactivity in six hours and then another one-half at the 12-hour mark, leaving one-fourth of its strength. The shorter the half-life the less radioactive exposure.

Material

The most common radioactive isotope used in radioactive tracers is technetium-99m, used in almost 30 million procedures in 2008, representing 80 percent of all nuclear medicine procedures, according to World Nuclear Association. It is an isotope of an artificial element,

technetium, with a half-life of six hours, which provides enough time to perform the necessary diagnostic procedures, but provides patient safety. It is versatile and can be targeted to a specific organ or body part and emits gamma rays that provide the necessary information. Other radioactive tracers include iodine-131 for thyroid conditions, iron-59 iron to study metabolism in the spleen and potassium-42 for potassium in the blood.

CT Scan

A major use of radioactive tracers involves computed X-ray tomography or CT scans. These scans constitute approximately 75 percent of medical procedures with tracers. The radioactive tracer produces gamma rays or single photons that a gamma camera detects. Emissions come from different angles and a computer uses them to produce an image. The treating physician orders a CT scan that targets a specific area of the body, like the neck or chest, or a specific organ, like the thyroid.

PET

Positron emission tomography, or PET, represents the latest technology to use radioactive tracers. It provides a more precise image and is used frequently in oncology with Flourine-18 as the tracer. PET is also used in cardiac and brain imaging with carbon-11 and nitrogen-13 radioactive tracers. Another innovation involves the combination of PET and CT into two images known as PETCT.

Thus the above few illustrations demonstrate that although the use of radiation has definitely increased the efficiency and pace of advance diagnostics and scientific and atomic researches but its over exposure is hazardous for human as well as animal and plant species.

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