Text 1

New advances in radiation biology

Humans are exposed to multiple physical, chemical and biological agents during their lifetime. Of these, ionizing radiation(s) has long been known to be deleterious after high-dose exposure (>100 mSv) predominantly due to cancer induction although very high dose exposures yield tissue damage and ultimately death. Ionizing radiations are widely used in society, play a key role in the treatment of cancer and are an important diagnostic tool. For radiation protection purposes, despite a century of study, the risk estimates for cancer induction in humans are extrapolated from the Japanese atomic bomb survivors, who were exposed to relatively high dose and high dose rates. Several studies of radiation workers have been undertaken as these populations were exposed to protracted low-dose exposures. From these epidemiological data, there has been a simple extrapolation of risk to low doses generally found in environmental and most occupational exposures. This has been the linear-no-threshold (LNT) model, which assumes a linear dose-response relationship between dose and risk. Currently, with the exception of radiotherapy, the doses that members of the population can be typically exposed to are lower than the doses typically received by the bomb survivors and are therefore in regions where little epidemiological data are available. Against a typical background dose of ~3 mSv/year, examples of routine medical exposures include 3 mSv for a breast mammogram and 0.7 mSv for a dental x-ray.

The LNT model has been an acceptable compromise with experimental data from radiation biology studies to some extent agreeing with it, although not exclusively. The relevance of the LNT approach has recently been sharply brought into debate with the observation of "non-targeted responses". These are responses which do not follow the standard model of radiation effects. The standard model has been based on direct damage to DNA, leading especially to the production of DNA double-strand breaks and the downstream biological consequences of these [5] (see Figure 1). Non-targeted responses include a range of effects such as the adaptive response, genomic instability and the bystander effect. The aim of this short review is to highlight the key aspects of these new findings.

The Bystander Effect

A major advance in understanding radiation effects has been the observation that cells can respond when their neighbours are irradiated, referred to as a bystander response. These responses were first clearly identified in 1992 when Nagasawa and Little observed, under conditions where only 1% of a population of Chinese hamster ovary cells grown in culture had been traversed by a densely ionizing α-particle, that 30% of the population nevertheless experienced the formation of damaged chromosomes. Further studies have shown evidence for these effects in a range of cell types and measuring a range of end-points, including damage to chromosomes, mutations, cell death and carcinogenesis measured using *in vitro* transformation assays. Many studies have shown that simply removing the medium from irradiated cells and transferring it to non-irradiated cells is sufficient to observe a bystander response. Another approach is to use sophisticated microbeams which allow individual cells within populations to be selected and irradiated with low doses of charged particles or x-rays. Microbeams have provided defining evidence for bystander responses and the mechanisms underpinning them. In all these approaches, several common features of bystander response have been observed. Firstly, the effect is observed at low dose (<0.2 Gy) and saturates at high dose. Secondly, two main routes of transmittance of the effect have been found: direct cell–cell communication via specific pores between cells called gap junctions and release of factors from irradiated cells into the medium. A range of factors has been observed to play a role. These include reactive oxygen species (ROS), which are highly reactive-free radicals produced during normal cellular oxygen metabolism and after radiation exposure, and other molecules including reactive nitrogen species, such as nitric oxide and small proteins called cytokines. All of these are also widely reported to be key signalling molecules in cell stress responses.

Despite advances in understanding of bystander responses, further studies on their role and relevance *in vivo* are required. An important issue is whether these responses are damaging or protective effects as that will ultimately determine any effect they have on dose-response curves at low dose. Other studies have shown protective responses such as switching off of cell division via differentiation and the removal of potentially damaged cells by cell-death processes. What will be critical is the relative role of these effects in tissues and individuals in determining overall cancer risk.

Fonte: doi:10.4028/www.scientific.net/DDF.347.35

Text 2

“Department of Energy moves forward with controversial test reactor” by Adrian Cho

The U.S. Department of Energy (DOE) announced today that it will go forward with plans to build a controversial new nuclear reactor that some critics have called a boondoggle. If all goes as planned, the Versatile Test Reactor (VTR) will be built at DOE's Idaho National Laboratory (INL) near Idaho Falls and will generate copious high-energy neutrons to test new material and technologies for nuclear reactors. That would fill a key gap in the United States's nuclear capabilities, proponents say. However, some critics have argued that the project is just an excuse to build a reactor of the general type that can generate more fuel than it consumes by "breeding" plutonium.

The VTR—also known as the Versatile Fast Neutron Source—would be the first reactor DOE has built since the 1970s. It would differ in one key respect from the typical commercial power reactors. Power reactors use a uranium fuel that contains just a few percent of the fissile isotope uranium-235 and is made to be used once and discarded. In contrast, the VTR would use a fuel richer in uranium-235 that would generate more high-energy neutrons as it "burned." Those neutrons could be used to test how new materials and components age within the core of a conventional nuclear reactor, a key factor in reactor design.

In principle, such a "fast reactor" could also convert nonfissile uranium-238 to plutonium-239, which could be extracted by reprocessing the fuel. Many nuclear engineers envision a future in which the world relies on such fast reactors and reprocessed fuel for its electricity. Critics of the nuclear industry argue that breeder reactors are unnecessary and risky, as they would establish an economy in plutonium, the stuff of nuclear weapons. Some critics say the VTR is a way to keep that controversial dream alive—although VTR developers do not plan to breed plutonium or reprocess fuel.

The VTR already has friends in both parties in Congress, which in September 2018 gave the project $65 million for this fiscal year—even before DOE had definitely decided it wanted the reactor. However, Pasamehmetoglu urges caution about interpreting the DOE announcement. Strictly speaking, he says, it means the project has passed the first of five milestones—known as "critical decisions"—and that DOE has decided it needs the VTR to fulfill its mission. "It's just a start," Pasamehmetoglu says. "It doesn't mean by any stretch of the imagination that DOE has said that they're going to go out and build this."

Still, Pasamehmetoglu is optimistic. Researchers will now start to work on a conceptual design. They are still a couple of steps away from hammering out a detailed cost estimate and schedule. But Pasamehmetoglu estimates the reactor would cost between $3 billion and $3.5 billion and says the goal is to get it running in 2026. It would be a small 300-megawatt reactor, most likely cooled with liquid sodium, that would not produce electrical power.

At the press conference, held with Fatih Birol, executive director of the International Energy Agency in Paris, Perry also announced $24 million in new projects on technologies to capture carbon dioxide emissions from industrial plants and sequester the gas underground. "We believe that you can't have a serious conversation about reducing emissions without including nuclear energy and carbon capture technologies," Perry said. He noted projections suggest that in 2040 the world will still depend on fossil fuels for 77% of its energy, and in just the next 18 months U.S. exports of liquid natural gas should climb 150%, Perry said.

Fonte: doi: 10.1126/science.aax1889

NOME COMPLETO: _____ DATA:_____

Questions 1-5 refer to TEXT 1

1. **Regarding Paragraph 1, it is NOT stated by the author, that:**
   a. Ionizing radiation exposures above 100 mSv may result in death to an individual.
   b. Ionizing radiation is a known cancer-inducing agent.
   c. Risk estimates for cancer induction are calculated using people exposed to atomic bombs.
   d. The only known deleterious effect after a dose higher than 100 mSv is cancer.

2. **Which of the following is NOT according to the text:**
   a. The linear dose-response relationship is a extrapolation of risk to low doses.
   b. Risks in radiotherapy do not follow a linear-non-threshold model.
   c. Little epidemiological data is available on populations exposed to low doses.
   d. The dose to one breast mammogram is approximately equal to a one year exposure from background dose.

3. **It IS correct, according to the author:**
   a. Radiation biology studies have fully confirmed the linear-no-threshold (LNT) model.
   b. Radiation biology studies have confirmed in part the linear-no-threshold (LNT) model.
   c. Radiation biology studies have not confirmed at all the linear-no-threshold (LNT) model.
   d. Radiation biology studies will not be able to confirm the linear-no-threshold (LNT) model.

4. **Regarding the Bystander Effect, it is NOT stated by the author that:**
   a. The cells that undergo a bystander response react when their neighbours are irradiated but are not themselves irradiated.
   b. A study from Nagasawa and Little in 1992 showed that α-particle irradiation to 1% of Chinese hamster ovary cells damaged chromosomes in 30% of the population.
   c. Bystander response has been demonstrated for damage to chromosomes, mutations, cell death and carcinogenesis measured using *in vitro* transformation assays.
   d. In the bystander effect, cells irradiated by alpha particles induce radiation damage to non-irradiated cells by charged particle delayed emission.

5. **Regarding the Bystander Effect, it is NOT in the text that:**
   a. The effect is observed starting from a low dose up to a certain dose value.
   b. Irradiated cells may release reactive oxygen species (ROS) and other molecules including reactive nitrogen species and small proteins called cytokines into the medium.
   c. Cells communicate via specific pores between cells called gap junctions.
   d. *In vivo* measurements has shown that the bystander effect always increases the damage rate and therefore results in a greater cancer radiation risk at low doses.

Questions 6-10 refer to TEXT 2

6. According to the first paragraph of Text 2, which of the following is NOT according to the text:

a. The US Department of Energy is moving to build a new type nuclear reactor.
b. The Versatile Test Reactor can produce plutonium.
c. This new reactor will be used for material research.
d. Both critics and proponents are favorable to this new reactor.

7. According to the author, the U.S. Department of Energy (DOE):

a. Has built dozens of reactors in the last 50 years.
b. Is not favorable to the VTR project.
c. Has moved forward to build a new commercial power reactor.
d. Will, in principle, increase the availability of plutonium-239.

8. **On the current stage of the development of the VTR, it IS correct to state that:**

a. Under construction, with $65 million used since 2018.
b. Has finished the project design, and ready to go forward with the construction.
c. Has finished the detailing costs, schedules and a conceptual project.
d. Has only stated intentions to the VTR project.

9. One of the objectives of the VTR to the U.S. Department of Energy outlined in Text 2 is:

a. To produce 300 megawatts of electrical power to the power grid in the US.
b. To demonstrate that a commercial power reactor can run on plutonium fuel.
c. To be able to understand and predict how components used to build conventional nuclear reactors wear from neutron interaction.
d. To produce nuclear weapons from the spent fuel.

10. Mark True or False to the following statements in Text 2.

( ) The VTR project is key to the development of technologies that capture carbon dioxide emissions.
( ) The VTR can, by 2040, help to reduce the dependence on fossil fuels by 77%.
( ) The U.S. Department of Energy's expectation is that the VTR will be operational in 2026.
( ) Liquid sodium will be used as a coolant for the reactor.
( ) The VTR is controversial because it will increase the availability of plutonium.

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