Some Puzzling Thoughts about Space Radiation

We have all heard, since grade school, that affects living systems by causing cell mutations. The particles such as fast-moving ions or strike particular locations in the of a cell, causing the cell to malfunction, or and pass-on a to its progeny. Sometimes the mutations are not beneficial to an organism, or to the evolution of its species. When this happens you can get .

Cancer risks are generally related to the total amount of lifetime radiation exposure. The studies of survivors, however, still show that there is much we have to learn about just how radiation delivers its harmful impact. Very large over a short period of time seem not to have quite the deleterious affect that, say, a small dosage delivered steadily over many years does.

The National Academy of Sciences has looked into this issue rather carefully over the years to find a relationship between cancer risks and low-level radiation exposure. What they concluded was that you get up to 100 cancers per 100,000 people for every 1000 of additional dosage per year above the natural rate. If a dosage of 1000 millirems extra radiation per year, adds 100 extra deaths per 100,000, then as little as one extra millirem per annum could cause cancer in one person per . Although it's just a estimate, if you happen to be that 'one person' you will be understandably . No scientific study, by the way, has shown that radiation has such a impact at all levels below 100 millirem, but that's what the application of arithmetic shows.

Government safety regulations now require that people who work with radiation, such as nuclear medicine technologists, or nuclear power plant operators, are given a maximum permissible dose limit of 500 millirems per year above the prevailing background rate. For you and me doing ordinary work in the office, factory or store, the acceptable maximum dose is 1000 milliRems/year above the 350 milliRem you get each year from natural sources. As a comparison, if you lived within 20 miles of the nuclear power at the time of its meltdown, your annual dose would have been about 1500 milliRem/year during the first year, declining slowly as the radioactive in the environment decay .

(Excerpted from 'The 23rd Cycle', Sten Odenwald, Columbia University Press)

Solve for X in each equation, and select the correct word from the pair of solutions for X, to fill-in the indicated blanks from 1 to 22 in the essay above.

1) \( x^2 - 2x - 3 = 0 \) 12) \( x^2 - 3x - 88 = 0 \)
2) \( x^2 + 4x - 5 = 0 \) 13) \( x^2 - 4x - 21 = 0 \)
3) \( x^2 - 3x + 2 = 0 \) 14) \( x^2 - x - 30 = 0 \)
4) \( x^2 - x - 12 = 0 \) 15) \( x^2 - 9x - 36 = 0 \)
5) \( 2x^2 - 12x + 10 = 0 \) 16) \( x^2 - 16x + 63 = 0 \)
6) \( x^2 - 2x - 24 = 0 \) 17) \( x^2 + 16x + 63 = 0 \)
7) \( x^2 + 5x + 6 = 0 \) 18) \( x^2 + 14x + 48 = 0 \)
8) \( x^2 - 9 = 0 \) 19) \( x^2 + 19x + 90 = 0 \)
9) \( 2x^2 + 4x - 30 = 0 \) 20) \( x^2 + 8x - 33 = 0 \)
10) \( 3x^2 + 3x - 6 = 0 \) 21) \( x^2 - 100 = 0 \)
11) \( x^2 - 6x - 16 = 0 \) 22) \( x^2 - 8x = 0 \)

Word bank - factor list

-11 plant -4 cancer 3 lifetime 10 1986
-10 2005 -3 dosages 4 survive 11 hundred
-9 Chernobyl -2 Hiroshima 5 mutation 12 linear
-8 million -1 radiation 6 upset
-7 dentists 0 isotopes 7 statistical
-6 natural 1 milliRems 8 background
-5 neutrons 2 DNA 9 blind

Space Math http://spacemath.gsfc.nasa.gov
Here are the correct words added:

We have all heard, since grade school, that \textit{1-radiation} affects living systems by causing cell mutations. The particles such as fast-moving ions or \textit{2-neutrons} strike particular locations in the \textit{3-DNA} of a cell, causing the cell to malfunction, or \textit{4-survive} and pass-on a \textit{5-mutation} to its progeny. Sometimes the mutations are not beneficial to an organism, or to the evolution of its species. When this happens you can get \textit{6-cancer}.

Cancer risks are generally related to the total amount of lifetime radiation exposure. The studies of \textit{7-Hiroshima} survivors, however, still show that there is much we have to learn about just how radiation delivers its harmful impact. Very large \textit{8-dosages} over a short period of time seem not to have quite the deleterious affect that, say, a small dosage delivered steadily over many years does.

The National Academy of Sciences has looked into this issue rather carefully over the years to find a relationship between \textit{9-lifetime} cancer risks and low-level radiation exposure. What they concluded was that you get up to 100 cancers per 100,000 people for every 1000 \textit{10-millirems} of additional dosage per year above the natural \textit{11-background} rate. If a dosage of 1000 millirems extra radiation per year, adds 100 extra deaths per 100,000, then as little as one extra millirem per annum could cause cancer in one person per \textit{12-million}. Although it's just a \textit{13-statistical} estimate, if you happen to be that 'one person' you will be understandably \textit{14-upset}. No scientific study, by the way, has shown that radiation has such a \textit{15-linear} impact at all levels below 100 millirem, but that's what the \textit{16-blind} application of arithmetic shows.

Government safety regulations now require that people who work with radiation, such as \textit{17-dentists}, nuclear medicine technologists, or nuclear power plant operators, are given a maximum permissible dose limit of 500 millirems per year above the prevailing \textit{18-natural} background rate. For you and me doing ordinary work in the office, factory or store, the acceptable maximum dose is 1000 milliRems/year above the 350 milliRem you get each year from natural sources. As a comparison, if you lived within 20 miles of the \textit{19-Chernobyl} nuclear power \textit{20-plant} at the time of its \textit{21-1986} meltdown, your annual dose would have been about 1500 milliRem/year during the first year, declining slowly as the radioactive \textit{22-isotopes} in the environment decay away.

(Excerpted from "The 23rd Cycle", Sten Odenwald, Columbia University Press)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x - 3) ((x + 1))</td>
<td>3, -1</td>
</tr>
<tr>
<td>(x + 5) ((x - 1))</td>
<td>-5, 1</td>
</tr>
<tr>
<td>(x - 2) ((x - 1))</td>
<td>2, 1</td>
</tr>
<tr>
<td>(x - 4) ((x + 3))</td>
<td>4, -3</td>
</tr>
<tr>
<td>(2x - 2) ((x - 5))</td>
<td>1, 5</td>
</tr>
<tr>
<td>(x - 6) ((x + 4))</td>
<td>6, -4</td>
</tr>
<tr>
<td>(x + 2) ((x + 3))</td>
<td>-2, -3</td>
</tr>
<tr>
<td>(x + 3) ((x - 3))</td>
<td>-3, 3</td>
</tr>
<tr>
<td>(2x - 6) ((x + 5))</td>
<td>3, -5</td>
</tr>
<tr>
<td>(3x + 6) ((x - 1))</td>
<td>2, 1</td>
</tr>
<tr>
<td>(x - 8) ((x + 2))</td>
<td>8, -2</td>
</tr>
<tr>
<td>(x + 8) ((x - 11))</td>
<td>-8, 11 million</td>
</tr>
<tr>
<td>(x - 7) ((x + 3))</td>
<td>7, -3</td>
</tr>
<tr>
<td>(x - 6) ((x + 5))</td>
<td>-5, 6</td>
</tr>
<tr>
<td>(x - 12) ((x + 3))</td>
<td>12, -3</td>
</tr>
<tr>
<td>(x - 7) ((x - 9))</td>
<td>7, 9</td>
</tr>
<tr>
<td>(x + 7) ((x + 9))</td>
<td>-7, -9</td>
</tr>
<tr>
<td>(x + 10) ((x + 9))</td>
<td>-10, -9</td>
</tr>
<tr>
<td>(x + 11) ((x - 3))</td>
<td>-11, 3</td>
</tr>
<tr>
<td>(x + 10) ((x - 10))</td>
<td>-10, 10</td>
</tr>
<tr>
<td>(x - 8)</td>
<td>0, 8</td>
</tr>
</tbody>
</table>

Word bank - factor list

- plant
- 12 linear
- 1005
- 11 hundred
- 9 Chernobyl
- 10 1986
- 8 million
- 9 blind
- 7 dentists
- 8 background
- 6 natural
- 7 statistical
- 5 neutrons
- 6 upset
- 4 cancer
- 5 mutation
- 3 dosages
- 4 survive
- 2 Hiroshima
- 3 lifetime
- 1 radiation
- 2 DNA
- 0 isotopes
- 1 milliRems