INVESTIGATION 5

HOW SENSITIVE ARE THE LUNGS TO RADON?

INTRODUCTION

The human lung is a complex and efficient respiratory organ, the major purposes of which are to bring life-giving oxygen into the body and to rid the body of toxic carbon dioxide wastes. Although the system is complex, closely regulated, and interconnected with the nervous and circulatory systems, the basic functioning of the lungs, and the respiratory system as a whole, are simple and easy to understand. Air enters through the nasal passages, where it is filtered and warmed. A series of passageways lead to the tiny air sacs in the lungs called alveoli, which have very thin walls and are richly supplied with blood. The transfer of gases (oxygen into the blood and carbon dioxide out of the blood) occurs by simple diffusion. Air is pumped in and out of the system in response to the movement of muscles in the chest cavity, which are controlled by the brain in response to prevailing blood conditions, especially the concentration of carbon dioxide dissolved in the blood. Inside the air passageways (trachea, bronchi, bronchioles) epithelial cells line and protect the airways, secreting mucus to help trap foreign substances, which are removed by the beating of tiny hairs called cilia.

As a consequence of the important role played by the respiratory system (exchange of gases between the outside world and the inside of the body), its principal protection against foreign substances cannot be provided by a thick skin, as in the outer body, but rather must be provided by a clearance system like the mucus and ciliary action provided by the epithelial cells. For most particulate matter, this protective system is perfectly adequate. In the case of some cancer producing substances, such as cigarette smoke and radon, the protective system is not able to prevent harm to the tissue.

When a radioactive substance like radon or one of its decay products, makes its way into the respiratory system, there are several factors that will affect the amount of damage that can be done to sensitive lung tissue. First there is the half-life of the radioactive material, which influences the probability that the material will decay and emit its alpha radiation *while inside the lungs*. Second there is the amount of energy at which the alpha particle is ejected; the higher the energy, the further the particle can penetrate a given tissue. [Analogy: Hank Aaron hits a baseball with considerably more energy than a little leaguer. Who do you suppose hits the ball further?] Third there is the thickness of the protective layer of cells (surface epithelial cells) through which the radiation must pass in order to strike the sensitive tissues (basal epithelial cells). Fourth, and finally, there is luck; the alpha particle may miss the nuclei of the sensitive cells through which it passes.

In this exercise you will explore the major elements of lung anatomy and how they interact with agents such as radon and cigarette smoke (called carcinogens) to result in lung cancer. Americans have found these topics to be relevant, in view of the fact that cigarette smoke and radon are the two leading causes of lung cancer in this country, and account for somewhere around 100,000 to 150,000 deaths per year.

OBJECTIVE

To examine those elements of lung anatomy that influence the body's response to carcinogens such as cigarette smoke and radon.

PROCEDURE

1. Examine the data presented in Table 1.

2. Design changes to the anatomy of the human respiratory system, so that radon damage could be reduced. Your new system should be capable of performing all the normal functions of the current human respiratory system, including interaction between the nervous system, musculature, circulatory system, and control feedbacks. The major difference should be the incorporation into your new system of an improved mechanism for preventing radon and smoking damage to the lungs. Draw a sketch of your new system on a separate sheet of paper.

DATA

Table 1. Some examples of alpha particle emitting radioactive isotopes that occur in the uranium-238 decay series. Included are each isotope's half-life, the energy of its emitted alpha particles, and the approximate range of penetration of the alpha particle into lung tissue.

Radioactive Isotope	Half-life	Energy of alpha particle (Mev)[1]	Approx. range in lung tissue (microns)[2]
radon-222	3.8 days	5.49	41
polonium-218	3 minutes	6.00	48
polonium-214	164 micro-seconds	7.69	71

[1] Mev is a unit of energy (million electron volts)

[2] Micron is a unit of length (one millionth of a meter)

ANALYSIS

3. Which of the radioactive isotopes listed in Table 1 would you least like to inhale into your lungs? Why?

4. Cell division (mitosis) occurs rapidly in the basal epithelium of the lungs. How is this relevant to radon induced lung cancer?

5. The layer of surface epithelium in the lungs is variable in thickness, but is usually about 40 to 80 microns thick. This outer layer produces a mucus that is about 10 microns thick. What do these thicknesses have to do with radon-induced lung cancer?

6. Describe your new and improved respiratory system in detail, including both its new added elements and features shared with the old system. Use additional sheets of paper, as needed.

7. Thanks to your uncle's new and innovative company, appropriately named RespiroTechnologies, Inc., and recent breakthroughs in medical transplant procedures, an opportunity exists to equip all Americans with your new and improved human respiratory system. Design and describe an effective marketing strategy for your system, targeting both smokers and household residents of areas known to have high radon concentrations.

CONCLUSIONS

8. List and describe three properties of radon (including its decay products) and three properties of human lungs that cause radon and lungs to be an unwanted combination.

9. Health officials have theorized that smokers may be at higher risk from radon exposure, because there may be a synergistic relationship between these two causes of cancer. Explain what this means.