HOW-TO-DO-IT

# Quantifying the Inhalation of Tar from Smoking: A Guided-Inquiry Activity

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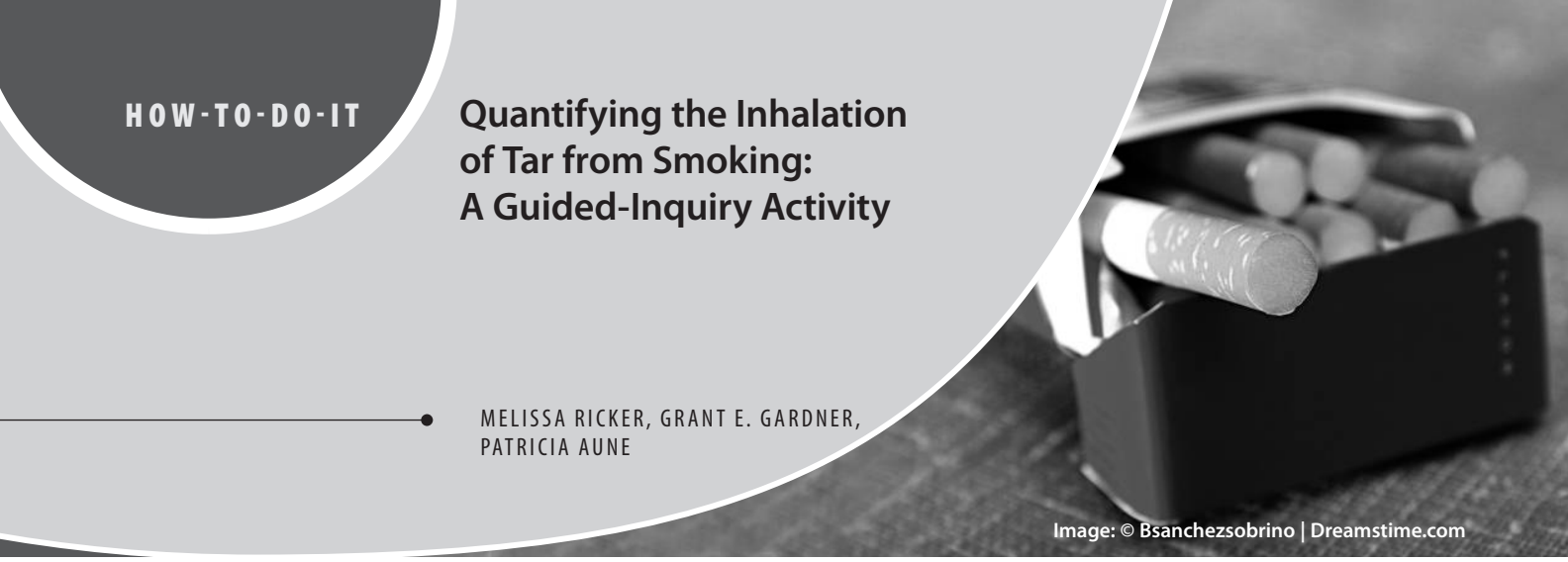

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**Abstract**

*Context-based laboratory activities are intended to engage students by utilizing personally relevant topics. In this short laboratory exercise we describe a method through which students engage in a health-related activity that highlights some of the dangers of nicotine inhalation, teaches relevant content, and provides a scaffold for the design of other inquiry-driven experiments.*

**Key Words:** *Smoking; guided inquiry.*

Despite targeted efforts on the parts of public health officials and both formal and informal educators, the use of tobacco products continues to be endemic in our country. In a recent report by the Centers for Disease Control and Prevention (CDC), it was found that 19.8% (43.4 million) of Americans were addicted to cigarettes, with nearly two-thirds of this population smoking every day (CDC, 2008). An estimated 98 billion dollars in productivity losses each year are due to smoking-related sick days and smoking on the job (CDC, 2001). In addition, in a social environment where health costs continue to increase dramatically, direct and indirect health costs related to tobacco contribute 6–14% of all total healthcare costs (Max, 2001).

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To make antismoking education more formalized, the Science, Tobacco and You program was created in 1999 in compliance with the *National Science Education Standards* (NSES) (Collins, 1998). The aim of this program was to provide structure and resources for teachers in grades 4–6 to engage in antismoking education with focused and measurable outcomes. The project is currently attempting to align its educational goal with individual state standards as well.

Antismoking curricula are encouraged in primary and secondary schools but have not been taught as prevalently after high school, when students might arguably be more at risk. In addition, smoking education is often limited to programmatic demonstrations in which students rarely engage in inquiry-oriented activities. This seems odd, considering that standards documents and education research have consistently demonstrated that the most meaningful form of science learning occurs when students are engaged in hands-on inquiry activities. There is a need for new and innovative approaches to antismoking education on college campuses (Paldy, 2001). In response to the demand for higher-level antismoking education, a smoking simulator module was created. This experiment is most appropriate for the high school and college-aged population and uses simple materials. The goals of this activity are threefold: (1) to assist in teaching relevant content related to smoking and its health effects, (2) to realistically highlight the results of smoking, and (3) to provide a scaffold for the design of additional inquiry-driven classroom activities.

## ○ Background

Formal and informal educators, as well as public servants (such as police officers), continue to introduce students to various educational approaches when teaching antismoking curricula. Often, materials like charts and graphs are used as visual representations to show why smoking is dangerous. One of the most popular graphs displays the annual deaths by numbers attributable to cigarette smoking (Figure 1). Economic arguments are also used to express what it costs to smoke. Frequent examples determine the amount of money that average people spend monthly and annually on cigarettes. Discussions are often facilitated, allowing students to share their experiences about how smoking has affected their lives in addition to learning from the others who share. All of these methods are used in an attempt to make the consequences of smoking seem real to a body of individuals who are often very risk-affinitive.

The Drug Abuse Resistance Education (DARE) program was created by the nonprofit DRUG America in 1983 for elementary and middle school students to learn about the dangers of smoking, tobacco advertising, and drug abuse. This program enabled students to interact with police officers or sheriffs in a classroom environment, contributing to the "real" factor. Despite the prevention approach and national curriculum execution, analysis of long-term effects proves the program to be ineffective. "In brief, the six long-term evaluations of the DARE elementary school curriculum that we reviewed found no significant differences in illicit drug use between students who received DARE in the fifth or sixth grade (the intervention group) and students who did not (the control group)" (Durbin, 2003).

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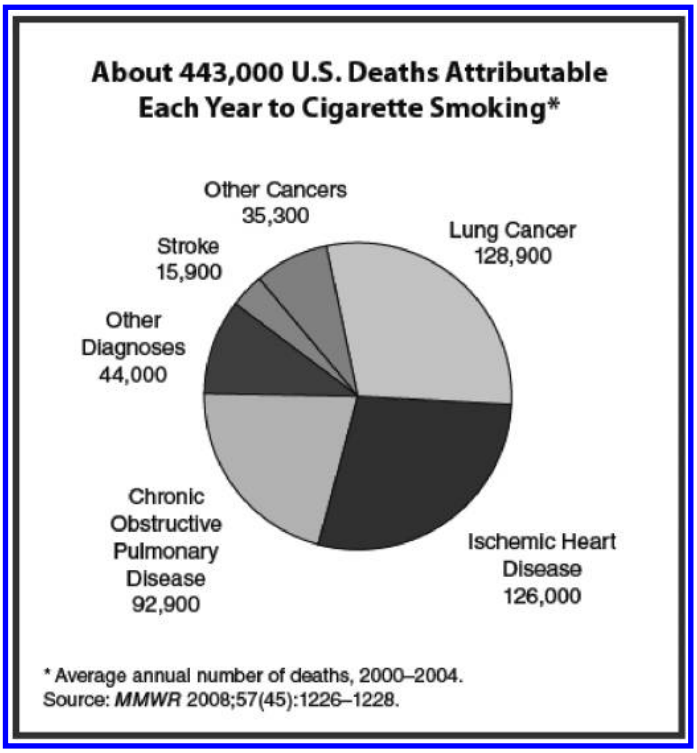


**Figure 1.** Graph courtesy of the Centers for Disease Control and Prevention (CDC, 2008).

**Figure 2.** Required materials.

## ○ Materials

The design of this module is to collect in a filter the accumulation of tar from a burning cigarette. The modest equipment requirements and relatively low cost of the setup allow for rapid preparation while maintaining a high tar accumulation. Materials are shown in Figure 2.

- 1 cigarette
- 60-mL plastic syringe
- 0.22-µm pore-size syringe filter
- 2 inches of 0.125-inch-diameter plastic tubing
- 2 inches of 0.375-inch-diameter plastic tubing
- 0.4-inch-diameter tube connector
- Parafilm

## ○ Protocol

1. Depending on the developmental level of the students, the instructor can prepare the apparatus beforehand or allow the students to assemble it themselves (Figure 3).

   *Apparatus Construction*

   a. Connect the two pieces of plastic tubing by wrapping a small amount of parafilm around one end of each. Place the two ends into the plastic tube connector, ensuring that there are no leaks.

   b. Wrap parafilm around the outside of the tube-connection sites to ensure no leakage.

   c. Place the other end of the 0.125-inch-diameter plastic tube into the longer nozzle of the 0.22-µm filter and attach the other nozzle of the filter to the 60 mL syringe.

   d. Place the cigarette inside the 0.375-inch-diameter plastic tubing.

2. Light the cigarette as the syringe is drawn. With each draw of the syringe, the pressure change pulls air through the cigarette, through the plastic tubing, through the filter, and into the syringe.
3. At the syringe capacitance for the average "puff" (50 mL), carefully pop off the syringe from the filter and release the air from the syringe.
4. Place the syringe back on the filter and continue the pattern of drawing air, releasing it from the filter, releasing air from the syringe, and returning the syringe to the filter.

## ○ Example Data

In order to get an accurate representation of the smoke inhaled by the average smoker, amount of air inhaled per puff of cigarette, and time between puffs, a previous research study was consulted for numerical values. Tobin et al. (1982) had 19 subjects smoke low-tar and high-tar cigarettes, measuring their inhalation. The results showed that puff volume varied from 39 ± 10 mL to 52 ± 15 mL, respectively. For simplicity, an average inhalation value of 50 mL was used. Tobin et al. (1982) reported a wide variety of values for time between puffs, so three trials were conducted testing how many puffs were reasonable, taking into consideration the variability of the time it takes to remove, empty, and replace the syringe and connect it to the filter. Forty puffs were sufficient in all trials and became the standard number used in this particular run.

For each of the 12 moderate-tar cigarettes, forty 50-mL puffs were inhaled using one cigarette per filter. The 12 filters were weighed and recorded both before and after "smoking" (Table 1).

The results show that an average change in weight of 0.0449 g ($P < 0.001$) of particulates (tar, carcinogens, etc.) were collected in the filters, which suggests a significant amount of particulate accumulation after one cigarette. Beyond the weight increase, there is a physical color change to the filter after just a few puffs, with thick dark residue building up around 20 simulated puffs. By the completion of the acitivity the filters were covered in thick, dark residue.

## ○ Extension

Although currently in development, we believe that this laboratory exercise lends itself to extended, authentic science-inquiry activities. Below we list just a few of the number variables that students could design and test in future inquiry-driven experiments.

- What is the variance in tar accumulation with filtered vs. unfiltered cigarettes?
- How do different brands of cigarettes compare in tar accumulation?

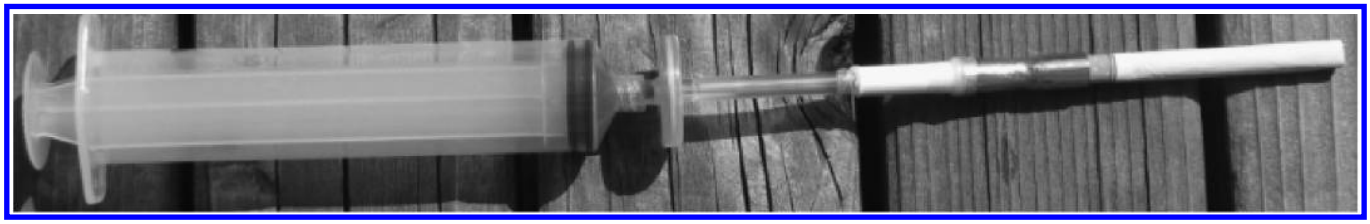

**Figure 3.** Inhalation apparatus.

**Table 1. Example data from experimental trial.**

| Trial | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight Before (g) | 3.9251 | 3.9545 | 3.9032 | 3.9249 | 3.9127 | 3.8913 | 3.9067 | 3.9362 | 3.9342 | 3.9412 | 3.9557 | 3.9024 |
| Weight After (g) | 3.9710 | 4.0017 | 3.9467 | 3.9648 | 3.9604 | 3.9582 | 3.9607 | 3.9807 | 3.9566 | 3.9704 | 3.9079 | 3.9524 |
| Change (g) | 0.0459 | 0.0472 | 0.0435 | 0.0399 | 0.0477 | 0.0669 | 0.0540 | 0.0445 | 0.0224 | 0.0292 | 0.0478 | 0.0500 |

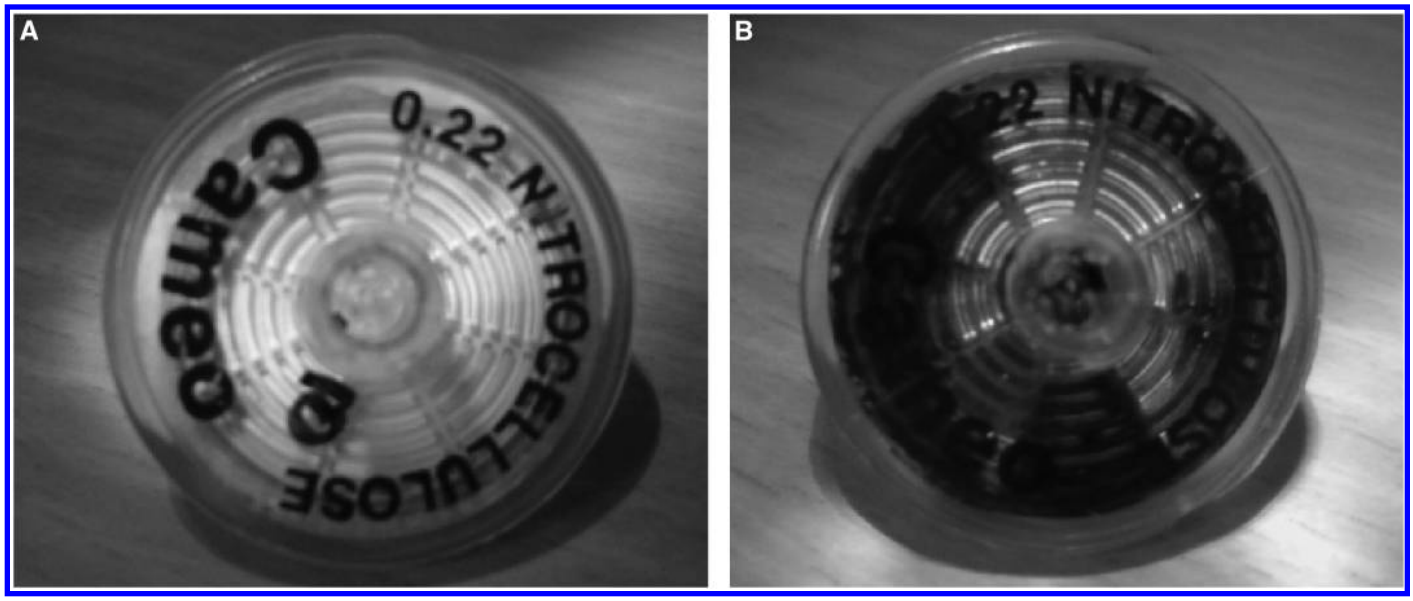


**Figure 4.** Images of the filters **(A)** before and **(B)** after "smoking."

- How do different lung capacities (represented by the size of the syringe) affect tar accumulation?
- How would varying the length of the "trachea" (plastic tubing) affect tar accumulation?

## ○ Conclusion

This model is adaptable to teaching how tar sticks to the semipermeable lung tissue and what residual tar looks like, incorporating principles such as diffusion and negative pressure changes pulling smoke into the lungs/through the filter. Aiding in the conceptualization of how smoking cigarettes causes damage to the lung tissues, the smoking simulator is an effective measure of the tar accumulation in the lung tissue after just one cigarette, making this a meaningful activity for students.

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