

## Day 4

### Cellphones: Safe or Carcinogenic?

With an estimated five billion worldwide users, the public debate over cellphone and the possible link to cancer is one of critical importance. The concern is that cellphones may cause the growth of any one of three types of tumors: cancer of the parotid (a gland near the ear), glioma (a rapidly spreading brain tumor), and acoustic neuroma (a tumor that typically develops on the nerve connecting ear and brain).

#### Scientist 1

There is growing evidence to support the conclusion that there may be a cellphone-cancer connection. The Interphone Study is the largest and longest study of cellphones and cancer. Including nearly 20,000 participants from 13 countries, the study found that those who used cellphones most frequently had a 40% higher incidence of glioma. Another peer-reviewed study conducted in Israel found that there was 58% greater occurrence of parotid tumors among heavy cellphone users. A Swedish survey of 16 scientific studies concluded that the incidence of acoustic neuroma and glioma was two times greater among those who used cellphones for 10 years. After reviewing a large collection of published studies, a group of 31 scientists from 14 countries commissioned by the World Health Organization classified cellphones as a possible carcinogen. This classification indicates that there is sufficient evidence of the connection to warrant further investigation and watchfulness. Reporting in an esteemed peer-reviewed journal, the National Institute of Health showed that a single hour of cellphone use significantly increases glucose metabolism rates at locations closest to the antenna. Even areas far from the antenna showed biological effects, a sign that the radiation may be capable of so-called non-thermal effects upon the brain. Cellphone radiation may be stimulating free radicals to destructive action or even initiate some form of inflammatory response within the brain. These could trigger a chain of actions that lead to tumor development.

#### Scientist 2

There is no credible evidence establishing a connection between cellphone use and cancer. Studies like the Interphone Study and others are observational studies that show only an association between cellphone usage and the occurrence of cancer. Such studies are biased in terms of how survey questions are asked of cellphone users who have acquired cancer. These methodological flaws do not lend credibility to their results. Statistical studies like these are not cause-effect studies. They do not isolate other variables and so they cannot determine that the cancer was actually caused by cellphone use. Furthermore, the tumors that are associated with cellphone use are so rare that even a doubling of probability of cancer would be equivalent to a small increase in the total numbers. Cellphones give off a form of radiation known as **nonionizing radiation**. The frequencies associated with this form of electromagnetic radiation are too low and the signal is too weak to be able to break biochemical bonds within body tissues and to be able to damage DNA molecules. Such effects are known as *thermal effects*. Study after study has shown that cellphone radiation does not have a thermal effect upon the brain; that is, it doesn't *fry our brain*. No scientist has yet proposed an acceptable biological mechanism to explain how cellphones can cause cancer via *non-thermal effects*. Simply speculating that there is increased glucose metabolism rate associated with cellphone use does not establish that cellphones cause cancer. Because there is no cause-effect model proposing how cellphones cause cancer, and because the studies associating cellphone use with cancer have obvious flaws, there is no reason for the general public to fear that cellphone use causes cancer.

## Day 4

### Questions:

1. The Interphone Study found a 40% higher incidence of glioma in heavy users of cellphones. The data from the study also found that the incidence of cancer among all cellphone users - from heavy to light use - was slightly less than the incidence of cancer among non-users of cellphones. How would **Scientist 1** most likely interpret the results of this study?
  - a. Heavy use of cellphones can cause cancer; light use of cellphones actually protects the user from cancer.
  - b. Statistical findings are highly unreliable and cannot be trusted as a source of evidence in the cellphone-cancer debate.
  - c. Averaging a large amount of data for many subjects in a study sometime produces less reliable findings than looking at the data for a smaller group of subjects.
  - d. It is important to sort the cellphone data into high use, moderate use and low use; the frequency of exposure plays a critical role in the probability of getting cancer.
2. Which one of the following statements would both **Scientist 1** and **Scientist 2** agree with?
  - a. Radiation must be of the ionizing form in order to cause cancer.
  - b. Cellphone radiation is dangerous because of its ability to break biochemical bonds in body tissue.
  - c. Surveys of cellphone users who develop cancer are an important source of evidence of the connection between cellphones and cancer.
  - d. To establish a cellphone-cancer connection, there must be some form of biochemical mechanism that explains the connection.
3. Cellphones are one of 900 environmental factors that the World Health Organization (WHO) has studied over the last couple of decades. The WHO categorizes these factors in one of five ways - definitely carcinogenic (107 cases), probably carcinogenic (59 cases), possibly carcinogenic (266 cases), definitely not carcinogenic (1 case), and non-classifiable (508 cases). An environmental factor receives the non-classifiable categorization if they are unable to reach an evidence-based conclusion. Which one of the following statements would best represents **Scientist 1's** response to the categorizing of cellphone radiation as possibly carcinogenic?
  - a. Cellphones are definitely cancer causing and should be banned until further research proves their safety.
  - b. The fact that the WHO has only placed one factor of 900 in the definitely not carcinogenic category indicates a strong bias.
  - c. The fact that WHO categorized cellphones as only possibly carcinogenic indicates that their study cannot be used to support the possibility of a cellphone-cancer connection.
  - d. The fact that WHO categorized cellphones as possibly carcinogenic indicates that they saw possible evidence for a cancer connection. In the absence of such evidence, they would categorize them as non-classifiable or not carcinogenic.
4. Which slogan below is inappropriately matched to the scientist's feelings regarding cellphone use and cancer?
  - a. **Scientist 1**: Better safe than sorry.
  - b. **Scientist 1**: Cellphones are guilty until proven innocent.
  - c. **Scientist 2**: Cellphones are innocent until proven guilty.

## Day 4

- d. **Scientist 2:** You can prove just about anything using statistics.
5. Which one of the following assumptions is **NOT** made by **Scientist 2**?
- The skull of the brain provides a protective barrier against cellphone radiation.
  - The radiation emitted by cellphones is not capable of thermal effects upon the brain.
  - Statistical studies are inferior to cause-effect studies and are subject to bias and methodological flaws.
  - To be considered cancer causing, it is important to identify the biological mechanism by which a factor causes tumor development.
6. Suppose that a biological mechanism attributing tumor development to non-thermal effects caused by cellphone radiation was proposed and then validated by a research study. Which statement describes the most likely effect that this development have on the thinking of the two scientists?
- Scientist 1** would no longer believe in the validity of statistical studies.
  - Scientist 1** would advocate research into thermal effects of cellphone radiation.
  - Scientist 2** would call for more statistical surveys of cellphone users who developed tumors.
  - Scientist 2** would accept the conclusion that there is evidence for a possible cellphonecancer connection.
7. The findings of the National Institute of Health that reported increased brain activity after an hour of cellphone usage was based on having the phone in receive-only mode. It is an established fact that the radiation signal is stronger when the phone is transmitting a signal. Which statement best describes the response of **Scientist 1** and **Scientist 2** to this fact?
- Scientist 1:** Cellphones should be immediately banned.
  - Scientist 2:** The study is biased because it failed to examine all the functions of cellphones.
  - Scientist 1:** If an effect is observed for the weaker signal, even greater caution should be adopted for the stronger transmission signal.
  - Scientist 2:** Statistical studies of cellphone users who acquired tumors should be performed to see how they most often used their cellphone.

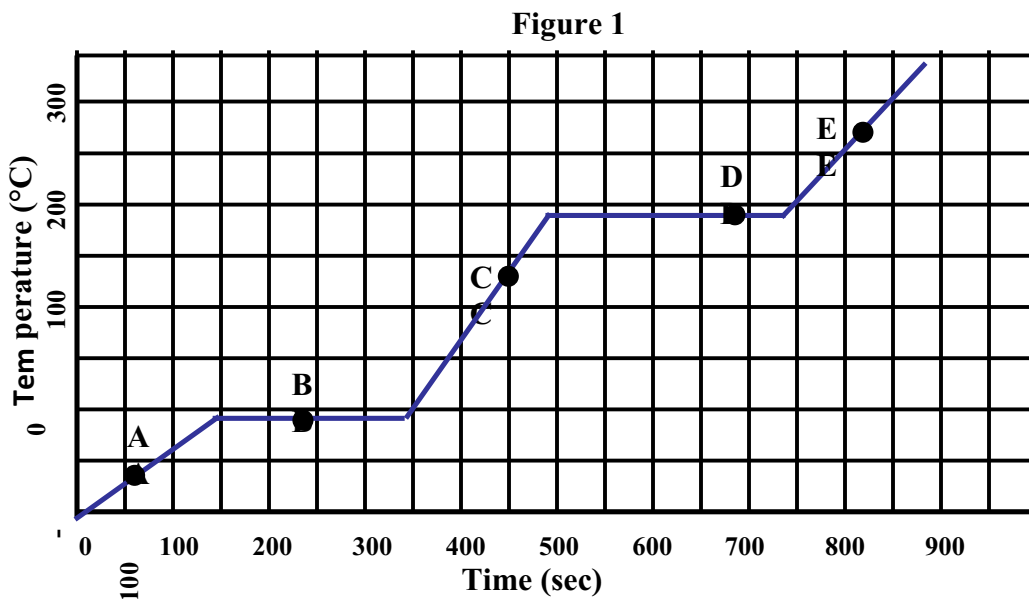
## Day 4

### Heating Curve

Most substances can exist in three different states – a solid, a liquid and a gas state. Changes from one state to another commonly occur by heating or cooling a sample of the substance. **Melting** refers to the change of a sample from the solid to the liquid state at its melting point temperature.

**Boiling** refers to the change of a sample from the liquid to the gaseous state at its boiling point temperature.

Consider a substance that is present in a sealed container in its solid state at a temperature well below its melting point. Over the course of about 15 minutes, the container is heated. At first, the application of heat causes the temperature of the substance to increase until it reaches its melting point temperature. At its melting point temperature, heat is continually added, causing the solid to transition to a liquid at a constant temperature. Once all the solid has melted, the substance is heated to its boiling point temperature. At its boiling point temperature, the addition of heat causes the liquid to transition to a gas at a constant temperature. Once all the liquid has boiled, the sample continues to be heated (cautiously), causing the temperature of the gas to increase. This process is depicted in **Figure 1**.

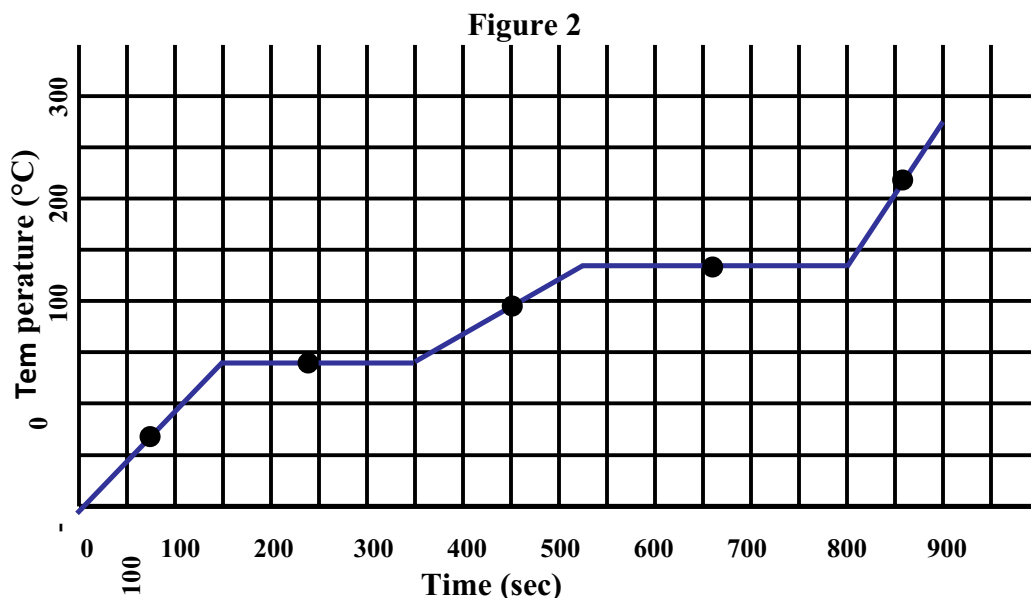


### Questions:

- According to **Figure 1**, at what temperature does the substance transition between the solid state and the liquid state?
  - Approximately  $-65^{\circ}\text{C}$
  - Approximately  $-7^{\circ}\text{C}$
  - Approximately  $135^{\circ}\text{C}$
  - Approximately  $190^{\circ}\text{C}$
- Which one of the following statements are true of the sample of matter described by **Figure 1**?
  - As heat is added to the sample, its temperature always increases.
  - The sample is melting between a temperature of about  $-100^{\circ}\text{C}$  and  $-10^{\circ}\text{C}$ .
  - The liquid state would be observed in the sample at both 200 seconds and 400 seconds.
  - The solid state would be observed in the sample at both 600 seconds and 800 seconds.

## Day 4

3. There are five labeled points on the line of the graph in **Figure 1**. What changes, in order, are observed in the sample of matter between **point A** and **point C**?
- First the sample melts; then its temperature stabilizes; then it boils.
  - First the sample increases its temperature; then it melts; then its temperature increases.
  - First the sample increases its temperature; then it melts; then its temperature stabilizes.
  - First the sample increases its temperature; then it melts; then it stabilizes its temperature.
4. There are five labeled points on the line of the graph in **Figure 1**. At which of the labeled points is the sample a mixture of liquid and gas?
- The sample is a mixture of liquid and gas at **point C**.
  - The sample is a mixture of liquid and gas at **point D**.
  - The sample is a mixture of liquid and gas at **point E**.
  - There could never be a mixture of both liquid and gas under these conditions.
5. Suppose that **Figure 1** represents the so-called *heating curve* for **Substance A**. **Figure 2** below represents the *heating curve* for **Substance B**.



What conclusion can be drawn regarding the melting points and boiling points of **Substance A** and **Substance B**?

- Substance A** has a higher melting point and a higher boiling point than **Substance B**.
- Substance B** has a higher melting point and a higher boiling point than **Substance A**.
- Substance A** has the higher melting point but **Substance B** has the higher boiling point.
- Substance B** has the higher melting point but **Substance A** has the higher boiling point.