Lesson Plan for DIFFUSION
Part 1: Simulation

Agenda:

- **Diffusion Science Detective's Notebook and simulation (40 minutes)**
- **Wrap Up (5 minutes)**
- **Something Extra: Doing Research**
  Find out how diffusion and convection are different at the particle level

Materials:

- **Computers**
- **Science Detective's Notebook #1: Diffusion**

Lesson Procedure:

Distribute Computers:

Go to: **www.create.nyu.edu/mm** and navigate to the diffusion simulation

Simulation Activity:

Students complete the Science Detective's Notebook while working through the diffusion simulation

Diffusion Simulation and Notebook: Content Overview and Teacher Notes
The lesson guides learners to a deep understanding of diffusion and some everyday examples of how diffusion can explain real-world phenomena! Diffusion describes how particles of matter move through other liquids and gases (including air). The Diffusion simulation explains how the mass of particles and temperature are related to how quickly particles travel over an area.

Entry 1: Make Observations and Propose a Hypothesis (10 minutes)

Students read a short narrative called "The Case of the Punk and the Popcorn"
Students read a short story on the diffusion of popcorn smell. Students are guided to think about why smell lingers and spreads through a room.

Students propose an explanation for the observation that the smell of popcorn was still in the room an hour later.

Entry 2: Explore A Model to Test Your Hypothesis

Students work through online tutorial and explore the diffusion simulation.
Students can change the temperature and the type of atom and observe how these variables affect the rate of diffusion. Students should also observe that molecules move randomly, move in straight lines and change direction when they collide with each other or the walls of the container.

Students record observations on the relationship between temperature and diffusion rate and between molecular mass and diffusion rate.
Students complete tables and graphs in their notebooks using the data generated by the simulation model.

Entry 3: Collect Your Data

Students analyze the data they have recorded from the simulation.
Students are guided to use the data they have collected to answer two main questions:

1. *What role does temperature play in diffusion?*
2. *How does the atomic/molecular mass of molecules of gas affect the rate of diffusion?*

Entry 4: Synthesize What You Learned

Students propose an explanation based on what they have learned in the simulation to explain how the popcorn smell spread.
Students should be able to explain that the popcorn smell lingered due to the slow diffusion of molecules through the apartment.

Entry 5: Generalize Conclusions

Students generalize their observations to rules about mass, temperature and rate of diffusion**:** *Student should conclude that molecules move faster at higher temperatures and particles with greater mass move more slowly.*

Entry 6: Something Extra – Conduct Research

Students conduct research to find out how diffusion and convection are different at the particle level.

Lesson Plan for DIFFUSION
Part 2: Lab/Demo

Aim: What is diffusion and what are some of the conditions where we can observe it?

Agenda:

- **Do It Now!** Review of Simulation (10 min)
- **Diffusion:** Definition and Generalizations (5 minutes)
- **Questions for Discussion** (10 minutes)
- **Graham's Law** (10 minutes)
- **Lab/Demo:** Diffusion of food coloring in agar Petri dishes (10 minutes)
- **Homework:** Write a story/comic

Materials:

- **Diffusion Lab Notebook**
- **Water**
- **Agar filled Petri dishes**
- **Food Coloring**

Lesson Procedure:

Entry 1: Do it Now!


Students complete review questions on simulation

Entry 2: Discussion Questions


Diffusion: describes how particles of one gas or liquid spread through another gas or liquid. It depends on the mass (or size) of the molecules and the temperature.
If the molecules are small, they travel quickly. If the molecules are big, they travel slowly. If the temperature is hot, molecules travel faster. If the temperature is cold, particles travel more slowly.

It is important to note that in liquids and gases, movement of particles (molecules) by convection is often a more significant factor than movement by diffusion, especially in open areas. Convection is a collective (group) property of molecules whereas diffusion depends on the motion of individual particles.


How is the diffusion we studied similar to and different from the diffusion we learned about in living environment (biology)?
Similar: traveling through another solution
Different: Energy requirements

Why didn't each gas particle always take the same amount of time to reach the detector?
(You may want the students to make notes)

Graham's Law of Diffusion (Optional)

The heavier the particle, the slower it travels.
Thomas Graham worked out that the rate at which the particles spread out is inversely proportional to the square root of their molecular weight. We can write his law as a mathematical equation that should agree with the results you got from the simulation:
$Rate_{He}/Rate_{Ar} = \sqrt{39}$(mass of Argon)/$\sqrt{4}$ (mass of Helium)

Questions for Students
1. So what do you predict about the rate of diffusion of Argon when compared with the rate of Helium? State this as a mathematical relationship.

Explore the rate of diffusion as a whole class or individually.
Students can check their results.

2. Why was your prediction supported or not supported?

How do we know whether the simulation is a good model?

One way we can address this question is to see whether it can be used to make a prediction.

But we can also see how it works with our experiences in our lives. You see diffusion everyday but perhaps not in the same form as the gases you studied in the simulation.

Student feedback about where they might observe diffusion (not just with gases) e.g. tea, coffee, cocoa, sugar

Entry 3: Demonstration/Student Activity: Agar and Food Coloring

This demonstration/activity is meant to show how diffusion occurs in different states of matter.

1. You can perform a demonstration using an air freshener that is sprayed into one corner of the classroom (One where you can depress the trigger and leave it would be the best and something that is super smelly). Students raise their hands when they smell the scent the air freshener and you see a wave of hands begin to appear as the scent spreads throughout the room.

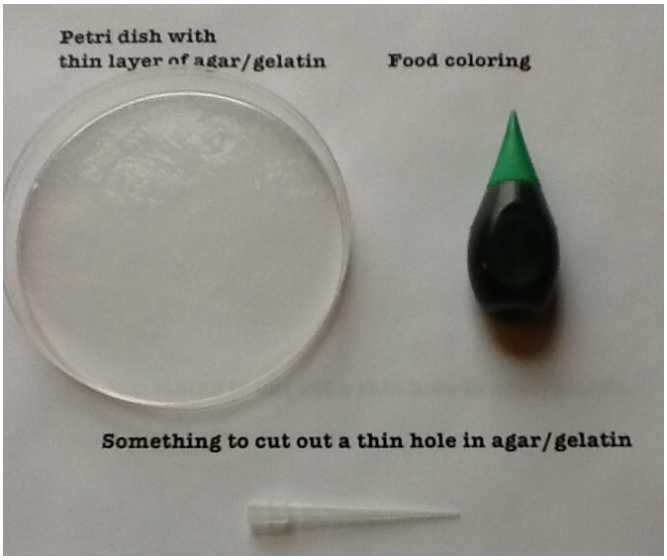
Research has shown that this demonstration is not just about diffusion but has a confounding variable since the spread of the air freshener throughout the room occurs through the mechanisms of both *diffusion* and *convection*.

But that's okay. After performing the demonstration, you ask students what are the two phenomena are at work to spread the air freshener scent around the room. And how can we isolate the phenomenon of diffusion from the effects of convection? This is where you can turn to activities using the agar plates or gelatin.

We can say that in these substances internal structures prevent the bulk flow of water (convection), so we can study diffusion in isolation from this confounding variable.

Then students can perform an experiment using the agar or gelatin.

Instructions for Activity
(This can be done by students working in small teams or as a demonstration)



1. Take a Petri dish with agar/gelatin, pipette tip or cork borer or something that can be used to make a small hole in the agar, food coloring.

2. Remove a small circle of agar from the center of the plate using the cork borer and place a small drop of food coloring in the circle.

3. Observe the rate of diffusion.

One thing they should notice is that pure diffusion is very slow over observable distances, which they can contrast with the quicker spread of scent from the air freshener (explained by convection and diffusion). They can also think about the rate of diffusion in solids and liquids when compared with gases. You might also ask students whether they would expect diffusion to be a little faster in gases and why.

Using this approach, students can learn about diffusion in the context of tackling a real world phenomenon that requires some thinking about how they might isolate and study a particular phenomenon.

Entry 4: Extension Activities

See student Diffusion Lab Notebook (page 24).

Sum it up!

Discussion about gases, liquids, and the effects of temperature and mass on the rate of diffusion. (Would Gabriella and her friends be able to smell the popcorn more quickly on a hot summer's day than a cold winter's day?)