Developing Possible Solutions

For any given problem, there is often more than one solution. In some cases, there are very few solutions. In others, a countless array of perfectly good solutions can be introduced. Without a system for testing each solution to figure out which is best, we'd have no quantifiable way of figuring out which one to choose.

Once a hypothesis, or potential solution to a problem, is in place, it needs to be tested. More than one hypothesis can be tested, and results should be carefully recorded.

Some solutions are more easily identifiable as being "the best." For example: the quickest route from home to school; the gear ratio that will make it easiest and most efficient to ride your bike; the best time of year to plant tomatoes. All of these solutions address very specific, concrete problems and are highly testable. And once you've found a satisfactory solution, you may not have to do too much testing. The solution will remain satisfactory indefinitely, as long as all other variables remain constant.

Of course, there are other problems we encounter where the solution set is wide-ranging and more open-ended.

Have you ever heard the expression "to build a better mousetrap"? It's an old saying that refers to a problem-solving endeavor that invites inventors and engineers to endlessly reimagine new and better solutions. In this case, the problem is very old and famously banal—catching mice.

Most mousetraps might look like the ones we see in a hardware store. But a new, improved design is always possible. It might be something completely different. Like an electrical current rigged with mouse-charming, atonal music; a gummy surface, following the principles of flypaper, designed to trap mice humanely; or, more organically, a housecat (with no bell).

In this case, depending on the goals and constraints of the project, an unending number of different solutions are possible. Scientists use many different techniques and resources to develop solutions—these include induction, ideas from other fields and research, their own creativity, mathematical calculations, and whatever else they may have access to. The inspiration for new and elegant solutions can come from an unexpected place. Just as artists look to the world around them for creative stimulation, scientists often take cues from the environment.

Although some people believe that artists and scientists do very different work, the two groups really have a great deal in common when it comes to problem solving and creativity.

The "stages of inquiry" a scientist goes through to come up with a satisfactory or plausible solution is sometimes romanticized in the annals of history. Throughout history, scientists have reported sensations of ideation that read thrillingly. Archimedes, for example, leapt out of his bathtub in a fit of inspiration. Eureka! (This means "I have found it!" in Ancient Greek.) Lightning may not strike every time, and most researchers learn not to rest on their laurels with that expectation. Still, many people who spend lots of time pondering difficult problems are familiar with the tickling sensation of a hunch or the satisfying power of a breakthrough.

After a solution or a set of testable solutions have been developed, the next step is to test them rigorously and systematically so that no aspect goes unexamined. In a controlled experiment, different groups of testable material are subjected to testing and compared with a control group for which outcomes are known. Experiments are usually regarded with a measure of skepticism themselves and are subject to change and redesign as the testing stage continues.

If the solution follows its predicted behavior—for instance, if the flypaper mousetrap in fact traps the mouse humanely, as desired—then it's a success. Funding is sought out for mass production of the flypaper mousetraps and investors start getting dollar signs in their eyes.

But maybe the flypaper mousetrap is faulty. Perhaps the mouse overpowers the adhesive on the trap and escapes easily. Or maybe the chemicals in the adhesive poison the trapped mice, nulling the mousetrap as a humane pest control option. There are always a number of things that can go wrong.

Once researchers observe problems with the proposed solution, they must go back and tweak the solution based on observed issues. In the case of our flypaper mousetrap, they'd have to look to the chemists who formulated the toxic adhesive. If one of the crucial goals of the mousetrap project was to leave caught mice unharmed, the process must prioritize that constraint. Once a new, non-toxic adhesive has been developed, the product will go back into testing. This process will be repeated until all of the conditions and constraints of the project have been satisfied.

This order of operations can go on for a long time. Some commercial products have appeared to meet all criteria in the lab, and once released to the general public, have failed, sometimes with dangerous results. Testing commercial products for commercial distribution is just one example of how the scientific method is applied carefully and comprehensively to make sure that solutions are as safe and successful as possible on the other end.

This stage and all stages of the scientific method are what we call *iterative*, meaning they are subject to repetition with the goal of achieving a desired goal or result. Scientists will test a solution over and over again, altering it each time until the results satisfy every criterion.

Failures can be discouraging, but they can also be instructive and useful! Certain kinds of failure may lead to reevaluation of the project's original intent and even redefinition of the elements. For example, if our mousetrap flypaper continues to fail—no matter how many times it is altered—there is something fundamentally incompatible with mice and tacky paper. Each constituent part would have to be investigated more deeply, and new conclusions drawn from that second cycle of research would be used to inform a new design. This can lead to amazing new discoveries.

Often a testing scenario will be conducted by a group of scientists, even generations of testers, as individuals pass in and out of the experiment. It can be helpful to introduce a new individual's perspective to the research—it's a creative collaboration that benefits from many minds at work, rather than just one.

A classical model of scientific inquiry was established a long time ago by Aristotle, who broke down reasoning into three categories: abductive, deductive and inductive inference. The distinctions between these three modes of problem solving have to do with how leaps in logic are made from one set of information to the next. Abduction has been defined as *guessing*, meaning it involves making certain assumptions that are only based on known results and not yet proven. Abduction relies more heavily on creative projection than deductive or inductive inference.

Inductive inference relies upon a degree of anecdotal support from past testing. Scientists take into account specific examples of how materials or organisms are known to behave and apply that information to make predictions about how situations involving similar materials or organisms will play out. Inductive reasoning is regarded as probable, meaning that it is not foolproof. It is only more *likely.*

Deductive reasoning is the inverse. Broad principles, rather than specific examples, are applied to specific materials, organisms or situations, and results are predicted based on those ideas.

All of these strategies are called into play in a testing scenario. As more information is pulled, testing scenarios can change and evolve. There is no satisfying a truly rigorous team of scientists. In designing solutions that meet every project constraint and push research to instructive new territory, it's necessary to keep asking questions and keep redesigning experimentation, even after a seemingly satisfactory solution has been achieved. This may seem like a frustrating burden to bear, but the results have led humankind to amazing progress. Patience with the testing process is ultimately rewarded not just with advanced, reliable solutions to everyday problems, but with new information that can be applied and reapplied to other scenarios as well.

Name: ______________________________________ Date: ________________________

1. What is used to determine whether a potential solution to a problem will actually work?

A creative stimulation
B lucky guesses
C old sayings and tickling sensations
D a test or series of tests

2. What sequence of actions is described in this passage?

A the steps taken to write a science textbook
B the steps taken to play atonal music
C the steps taken to solve a problem
D the steps taken to interview a scientist

3. Read this sentence: “For any given problem, there is often more than one solution.”

What evidence from the passage supports this statement?

A Catching mice can be done by using electricity, a sticky surface, or a cat.
B Abductive reasoning involves making assumptions based on results that have not been proven.
C Artists and scientist have a lot in common, though many people do not realize it.
D The word “eureka” means “I have found it” in Ancient Greek.

4. What is one way that testing helps scientists determine which solution for a problem works best?

A Testing allows scientists to choose a solution without having to spend time thinking about it.
B Testing allows scientists to rely on abductive reasoning rather than inductive and deductive reasoning.
C Testing allows scientists to compare the effectiveness of different solutions with each other.
D Testing allows scientists to ignore the seriousness of a problem and the importance of solving it.

5. What is this passage mainly about?

- **A** the discoveries of Archimedes
- **B** determining the best time of year to plant tomatoes
- **C** flypaper mousetraps
- **D** solving problems

6. Read the following sentence: "For any given problem, there is often more than one **solution**."

What does the word **solution** mean?

- **A** disaster
- **B** scientist
- **C** answer
- **D** artist

7. Choose the answer that best completes the sentence below.

One problem may have many possible solutions, _______ it is important to perform tests in order to choose a solution.

- **A** as an illustration
- **B** so
- **C** instead
- **D** before

8. What are the three categories of scientific reasoning described by Aristotle?

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9. What is deductive reasoning?

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10. Explain how one of the three types of reasoning identified by Aristotle could be used in developing solutions.

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Teacher Guide & Answers

Passage Reading Level: Lexile 1220

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8. What are the three categories of scientific reasoning described by Aristotle?

Suggested answer: The three categories of scientific reasoning described by Aristotle are abductive, inductive, and deductive reasoning.

9. What is deductive reasoning?

Suggested answer: Answers may vary, but students should grasp that deductive reasoning is the use of general principles to make predictions about specific situations.

10. Explain how one of the three types of reasoning identified by Aristotle could be used in developing solutions.

Suggested answer: Answers may vary, as long as they are supported by the passage. For example, students may respond that abductive (or inductive or deductive) reasoning could be used to form a hypothesis, whose efficacy as a solution would then be tested.