# WHAT DOES A GAME HAVE TO DO WITH ASTRONOMY?

**AST 114 @ MESA COMMUNITY COLLEGE**

**NAME**: ________________________________ **DATE**: ____________________________

## INTRODUCTION

This lab exercise introduces the concepts of scientific inquiry.

## LEARNING GOALS

- Identify patterns in data.
- Propose scientific hypotheses.
- Test predictions using observations.

## EQUIPMENT

- astronomy game board and playing pieces
- computer with web browser

## LEARNING THE RULES OF THE GAME

Your group will receive materials to play a simple game and a sequence of moves for several different sessions of that game. The winner of a particular game session, if any, is indicated at the conclusion of that set of moves. Your goal, working as a group, is to discover the rules of the game based on the game design and the players' moves. You should assume that the players know how to play the game, but they may not be expert players.

1) Play through the sequences of game moves, one game at a time. List, in the space below, each rule you develop that appears to explain the game moves. If you discover that one of your rules can be eliminated by moves that occur in a later game, cross the rule out or place an "X" next to it. *Be as complete as you can*.

2) When all groups are done analyzing the player moves, your instructor will invite you to share rules from your complete list. List any rules not discovered by your group in the space below.

3) Which rules in your list for Question 2 are you most certain of? List them below.

4) What might allow you to be more certain of those rules you do not feel confident in?

5) What might allow you to discover additional rules that you did not list in Question 2?

## HOW DOES SCIENCE WORK?

Answer the following questions based on the game activity.

6) Did all groups come up with identical rules? YES <u>or</u> NO

Each rule of the game you developed can be thought of as a *hypothesis*. Simple hypotheses can be written as "if, then" statements, such as:

*If the Sun is a star, then other stars should have the same properties as the Sun.*

7) Rewrite one of the rules you listed for Question 3 as an "if, then" hypothesis.

8) All groups had <u>identical sets of game materials</u> (boards, playing pieces, and sets of moves). What might cause different groups to discover different sets of rules for the game?

9) Did you keep every rule you listed in Question 1? YES <u>or</u> NO

10) What caused you to reject some of the rules you proposed after you examined a few games?

11) Do you think you discovered every rule of the game? YES <u>or</u> NO

12) The set of rules you feel certain of can be thought of as your *model* of the game. Review Question 3 and write a short summary of your model (the rules) of the game. Identify the parts of the model you are most certain of and those parts you think need additional testing.

13) What would you need to complete your analysis of the game in order to feel confident that you discovered a 100% complete model of the game's rules?

**THE SCIENTIFIC METHOD**

The game activity you just completed illustrates many of the features of the *scientific method*. This process is often described as follows: (a) propose a hypothesis, (b) make specific predictions based on your hypothesis, (c) observe the natural world or conduct an experiment, (d) test your predictions against your measurements or observations, (e) conclude whether your hypothesis is valid or should be rejected. These steps may be repeated over and over until a successful hypothesis is discovered and validated.

Often this process is messier than the five steps listed above. An unexpected observation or measurement may prompt a new hypothesis. A flash of insight or a new way of viewing the world may trigger scientific investigation. A new measuring tool such as a telescope or lab apparatus may allow an existing hypothesis to be retested with more precision.

14) What might cause two scientists to propose two different hypotheses to explain the same feature of the natural world?

15) A scientist performs an experimental test of their hypothesis. The results do not agree with the predictions of the hypothesis. What should the scientist do with their hypothesis?

16) A scientist performs 3 experiments to test a new hypothesis. The results of all 3 experiments agree with the predictions of the hypothesis. Can the scientist be 100% certain of their hypothesis after this testing? Explain your reasoning.

17) The scientist performs 5 more experiments. The results of all 8 experiments agree with the predictions of the hypothesis. Can the scientist be 100% certain of their hypothesis now? Explain your reasoning.

18) Consider the statement: "The best scientific hypotheses are 100% correct." Do you agree or disagree? What is correct or wrong about this statement?

19) Not all hypotheses are scientific. "*Black holes form when invisible dragons flap their wings*" is an *un*scientific hypothesis. Why can't this hypothesis be tested?

20) Use the space below to describe a testable hypothesis of your own invention that explains a feature of the Universe around you. Ask another group to design a test of your hypothesis. Describe both your hypothesis and their test in the space below.

## SCIENTIFIC MODELS

Scientific hypotheses are generally short, simple statements about a specific feature of the natural world. For example, "The Sun contains a large amount of very hot gas" is a hypothesis. This statement can be tested and the hypothesis may pass or fail. But this simple hypothesis does not say anything specific about the Sun's interior: how hot, how dense, which gases, etc.

A *scientific model* is a more complete description of a natural phenomenon or object that includes several testable hypotheses. For example, a model of the Sun might include hypotheses about the chemical composition of the gas, how the temperature changes from center outward, its rotation, its magnetic fields, etc. Models themselves can be simple or complex. A simple model of a star may only describe its size and color. A complex model of a star might also describe the process by which stars generate their energy or how they change as they age.

21) List at least 3 hypotheses that form the basis of our modern model of the Sun.

*22)* Choose one of the hypotheses you listed above. Describe a method for testing the hypothesis. You may assume you can gather any measurements or observations you would need. Be specific about how your experiment tests the hypothesis and what data your test requires. *You do not need to carry out the procedure you describe!*

## MAKING PREDICTIONS, TESTING MODELS

By 1900, astronomers had photographed many hundreds of "spiral nebulas". It was not well understood what these objects were at that time. One model explained these objects as the birth places of new stars and planets within the Milky Way galaxy. In this interpretation, the spiral nebulas were small, rotating, slowly-collapsing clouds of hot gas and dust.

An alternate model of that time explained the spiral nebulas as "island universes" similar in size and structure to the Milky Way. In this second interpretation, the spiral nebulas were enormous collections of stars and many dark clouds of gas held together by gravity.

In 1900, telescopes were not powerful enough to observe directly what the spiral nebulas were made of, how far away they were, or how hot or cold they were.

23) According to the *star-birth* model, what would future astronomers detect when they measured a spiral nebula: the glow of hot gas or starlight? Explain your reasoning.

24) According to the *island-universe* model, what would future astronomers detect when they measured a spiral nebula: the glow of hot gases or starlight? Explain your reasoning.

25) Were the spiral nebulas inside or outside the Milky Way galaxy…

…according to the *star-birth* model?

…according to the *island-universe* model?

By the 1920's, astronomers like Vesto Slipher of Lowell Observatory in Flagstaff, Arizona, were using improved instruments to study spiral nebulas. Slipher and others detected the signature of stars but not hot, glowing gas in the light emitted by the spiral nebulas.

26) Which model – *star-birth* or *island-universe* – was supported by these observations? Explain your reasoning.

27) By 1925, Edwin Hubble had reliably measured the distance to one spiral nebula, the Great Nebula in Andromeda, and discovered that it was millions of light-years away. Which model did Hubble's distance measurement support? Explain your reasoning.

28) A few years later, Hubble and his assistant Milton Humason were able to observe that nearly all spiral nebulas were rushing away from our location in the Milky Way. Additional observations showed that these same spiral nebulas were many millions of light-years away. Did these observations support the *star-birth* model or the *island-universe* model? Explain your reasoning.

29) What name do astronomers now use to refer to these "spiral nebulas"?

**CONCLUSIONS**

Answer the following questions using complete sentences.

30) Explain the concept of a *scientific hypothesis*. Give one example.

31) Explain the concept of the *scientific method*.

32) *Scientific models* can be imagined in several ways: physical, visual/graphical, mathematical, or verbal/written. In the space below, provide one example of each type of scientific model.

A physical model:

A visual/graphical model:

A mathematical model:

A verbal/written model:

33) Describe the difference between the *scientific method* and a *scientific model*.

34) Explain the purpose of observation and experiment in the scientific method.

35) Evaluate the following statement: “Evidence is more important than proof in science.”