



The Scientific Method

ENVS 10
Lecture 2



Definition of “Science”

- ◆ Science – “to know”
- ◆ Way of asking questions about the world and sometimes obtaining precise answers to them
- ◆ Emerges from our curiosity about ourselves, the world, and the universe



The Nature of Science

- ◆ Guided by natural law
- ◆ Explanatory by reference to natural law (not the supernatural)
- ◆ Testable against the observable world
- ◆ Conclusions are tentative and therefore not the final word
- ◆ Falsifiable

Two Approaches to Science

◆ Discovery Science

- ❖ Verifiable observations and measurements
- ❖ Allows biologists to describe life on many levels
 - ◆ E.g., Darwin's descriptions
 - ◆ E.g., Human genome project
- ❖ *Inductive* reasoning
 - ◆ An inductive conclusion is a generalization that summarizes a large number of specific observations
- ❖ Ideally, investigations in discovery science use the scientific method

Two Approaches to Science

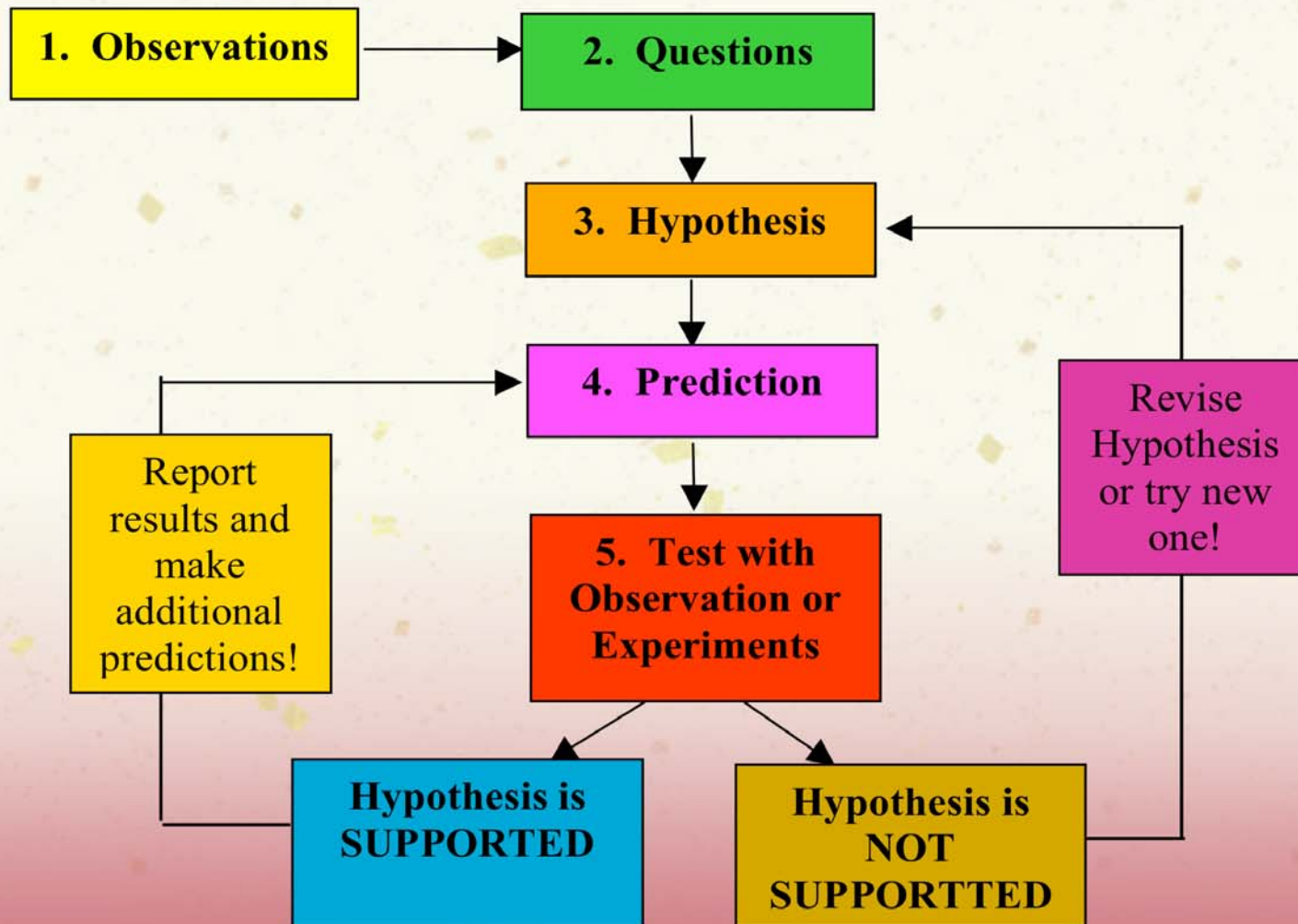
◆ Hypothesis-Driven Science

- ❖ Most modern scientific investigations
- ❖ Uses the Scientific Method
- ❖ *Deductive* Reasoning
 - ◆ Reasoning flows in opposite direction of inductive - from general to specific

The Scientific Method

- ◆ A formal process of inquiry designed to answer questions
- ◆ Follows a series of steps
- ◆ Must be repeatable
- ◆ Hypothetico-deductive method
 - ❖ Hypothetico = hypothesis (possible answer to a question)
 - ❖ Deductive

The Scientific Method



Step 1: Observation

- ◆ “Unexpected observation”
- ◆ Use any of the 5 senses to gather empirical evidence
- ◆ *Observation:* At zoo, male peacocks with the most ornate feathers are surrounded by females...hmmmm

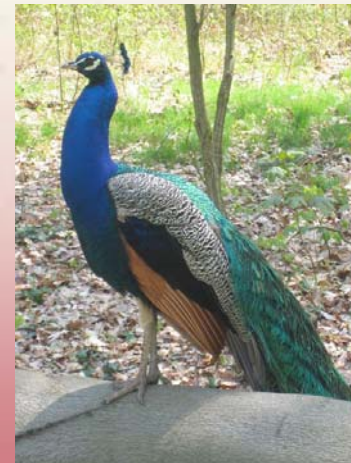


Photograph by Medford Taylor

<http://animals.nationalgeographic.com/animals/birds/peacock.html>

Step 2: Ask a Question

- ◆ Must be answerable
- ◆ Must be original
- ◆ Background research - who has asked similar questions or done research on this species/system?
- ◆ *Question:* What is the function of male peacock feathers?



Step 3: Make Hypothesis

- ◆ Tentative explanation for what we have observed - “Explanation on trial”
- ◆ Peacock Hypothesis – peacock feathers function to attract females

Step 3: Hypothesis (cont.)

◆ Make a null hypothesis

- ❖ A hypothesis set up to nullify in order to accept an alternative hypothesis
- ❖ Reject or fail to reject null hypothesis only!
- ❖ Typically, null hypothesis is one you hope to reject so you can accept the alternative
- ❖ Examples
 - ◆ H_0 : Ornate peacock feathers do not attract mating females
 - ◆ H_1 : Ornate peacock feathers do attract mating females



Step 4: Predictions

- ◆ Results of experiments we should expect *if* our particular hypothesis is supported
- ◆ Peacock Prediction: Non-ornate males will be approached less frequently by mating females than males with ornate feathers

Step 5: New Observations or Experiments

◆ New Observations

- ❖ Gather new information using specific measurements (e.g., frequency of female approach)

◆ Experiment: recreate an event or occurrence to get info to test your hypothesis

- ❖ Variables: things or events that can affect the event/occurrence

Step 5 (cont): Experiment

- ◆ Controlled Experiment - designed to test groups are treated alike except for the one variable the experiment is designed to test
 - ❖ Control Group (no treatment)
 - ❖ Experimental Group (treated)
 - ◆ Independent variable: scientist manipulates this variable (i.e., coloring or plucking of peacock feathers)
 - ◆ Dependent variable: changes based upon the independent variable (i.e., frequency of female approach – “preference”)

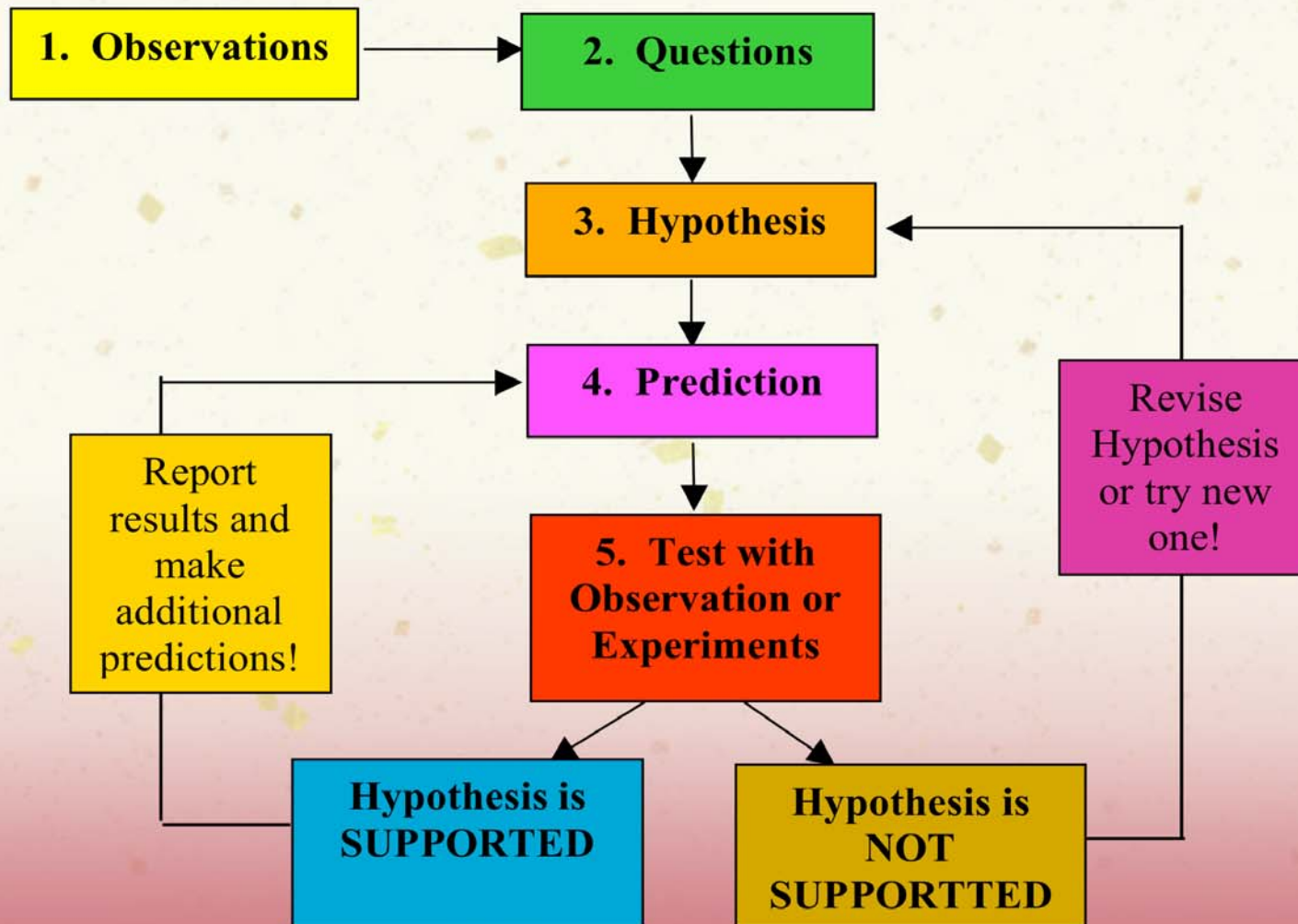
Step 6: Results

- ◆ What do your data show?
 - ❖ Frequency of female approach was not significantly different between ornate and non-ornate males
- ◆ Do they meet your predictions or do they not?
 - ❖ No! Fail to reject the null hypothesis!

Step 7: Support or Reject Hypothesis

- ◆ Hypothesis is **SUPPORTED**: Report results and develop new predictions or new questions
- ◆ Hypothesis is **NOT SUPPORTED**: You can revise hypothesis or make new ones

The Scientific Method



Important Considerations

- ◆ Supporting a hypothesis does not necessarily make it true (remember the null concept - reject or fail to reject). There are other variables to consider.
- ◆ To prove a hypothesis you need to test all possible alternatives! - usually impossible

Confer with other research:

- ◆ See how your research fits with current scientific theories and laws
 - ❖ Theories: widely accepted, plausible generalizations about fundamental concepts that describe why things happen
 - ◆ What is difference between a theory and a hypothesis?
 - ❖ Law: uniform or constant fact of nature that describes what happens in nature



Use the Scientific Method to Evaluate Environmental Issues

- ◆ Review scientific data on BOTH sides of the issue
- ◆ Look at the Weight of the Evidence (how much data, strength of conclusions, etc.)
- ◆ Look at the Scientific Consensus (how many other scientists agree, who are they?)

How does scientific knowledge advance?

- ◆ Interest!
- ◆ Robust, unbiased, ethical research
- ◆ Defendable and repeatable study design provides for defendable results

Let the evidence (data) LEAD YOU to conclusions - not the other way around!



How does scientific knowledge advance?

◆ Sharing of Knowledge

❖ Research and Publication

- ◆ Build hypotheses from the results of previous, robust research experiments and observations

❖ Conferences

- ◆ Present findings and interact with other scientists

❖ Internet communication

◆ Funding

- ◆ Obtaining grants and other sources of funding for research

Pseudoscience

- ◆ “False” science
- ◆ Opinion or advertising disguised as science
- ◆ Not tested through or faulty use of the scientific method
- ◆ Examples:
 - ❖ “Flat Earth Society”
 - ❖ Weight loss pill claims

The Case of the Ivory Billed Woodpecker

- ◆ *Campephilus principalis*
- ◆ Average lifespan in the wild: 20 to 30 years
- ◆ Size: 18 to 20 in (46 to 51 cm); Wingspan, 30 to 31 in (76 to 79 cm)
- ◆ Weight: 16 to 20 oz (450 to 570 g)
- ◆ Protection status: Endangered



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ Once ranged from east Texas to North Carolina, from southern Illinois through Florida, and south to Cuba.
- ◆ In the US - primarily among swampy bottomland hardwood forests, preferring wilderness and the deep cover of old-growth woods, (James Tanner, Cornell University, 1930's)



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ **Diet:** insects (primarily beetle larvae), sometimes fruits/nuts.
- ◆ **Feeding behavior:** To get to the beetle larvae, the birds strip the still-tight bark from recently dead trees with their enormous ivory-colored bill
- ◆ **Habitat Requirements:** extensive habitat of mature forests with many recently dead, but still standing, trees where the beetle larvae live.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ **Flight:** Ivory-bills don't have the undulating flight that is characteristic of many other woodpeckers - flight is strong and direct.
- ◆ When traveling any distance, they typically fly above the trees to avoid navigating through branches.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ **Call:** nasal-sounding "kent," often described as sounding similar to the toot of a tin horn.
- ◆ **“Double-knock”:** when striking a tree with their beaks - hypothesized that used to announce presence.
- ◆ Most woodpeckers in the ivory-bill's genus (*Campephilus*) make a similar double-knock, but all the other species live in Latin America.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ **Historical perspective:** Bills used as decorations by Native Americans, and a thriving trade in the bills existed across much of North America
- ◆ First described as "largest White-bill Wood-pecker" in 1712 by Mark Catesby from England



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ Pre Civil War: woodpecker thrived on the great expanses of virgin timber that covered much of the South
- ◆ Post Civil War: the lumber industry took off and the great trees of the South were felled to feed a nation starved for wood, wood, and more wood.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ Habitat destruction continued unabated through the 1940s until suddenly, there was no more timber left to cut.
- ◆ Habitat destruction forced the ivory-bill into smaller and more fragmented pieces of forestland. This loss of habitat certainly pushed this magnificent bird of the forest toward extinction.
- ◆ Bird collecting - another factor contributing to the demise of the ivory-bill once it became rare.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ Believed to be extinct - not documented since 1944
- ◆ Some expeditions from 1940's on found scant evidence
 - ❖ Birder reports
 - ❖ Lack of hard evidence



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ The world's third largest woodpecker was condemned to oblivion some 50 years ago, expeditions turned up no results - no hard evidence!
- ◆ April 2005, a video emerged from a vast Arkansas swamp forest. The tape confirmed** the sighting of a live ivory-billed woodpecker—and captured the attention of the world. It was hailed as the birding equivalent of finding Elvis alive.



National Geographic

The Case of the Ivory Billed Woodpecker

- ◆ In the wake of the discovery, some experts supported the evidence while others suggested that the tape showed a similar, smaller woodpecker—the pileated—which remains common in much of North America.



National Geographic

The Case of the Ivory Billed Woodpecker

◆ Assignment:

- ❖ Read the Case Study
- ❖ **View the video online!**
- ❖ Review questions 1 (pg 1) and 1-10 (pg 4)
- ❖ Come to class ready to discuss your answers!



National Geographic