

Chapter 1

Can Science Cure the Common Cold? Introduction to the Scientific Method

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1.1 The Process of Science

- Initially, scientists make an _____
- Observing leads them to a question they want to answer...

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The Process of Science

- This question is turned into a _____ – or a tentative answer to the question
- The hypothesis must be _____ and _____

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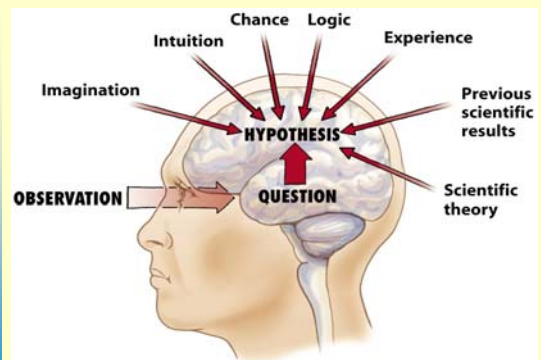


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The Logic of Hypothesis Testing

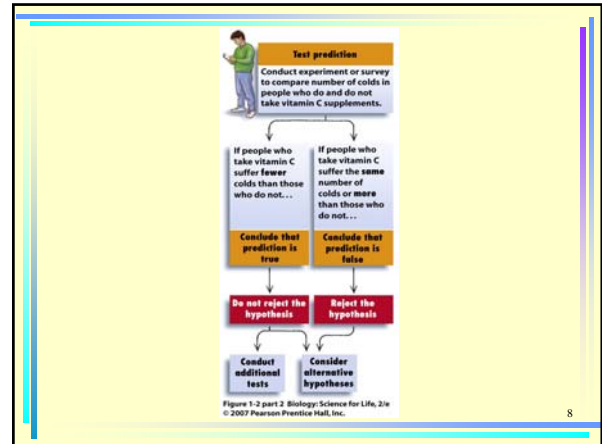
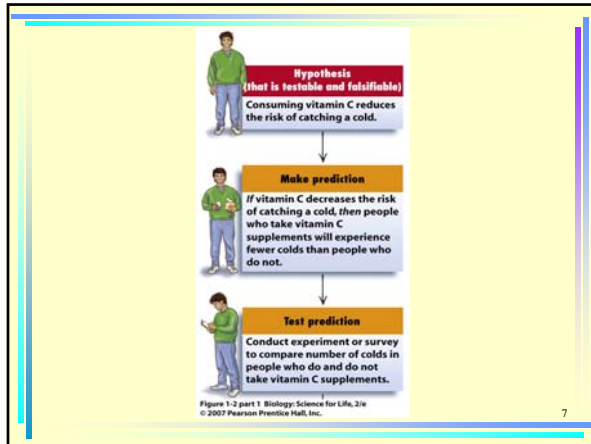
- Consuming vitamin C decreases the risk of catching a cold
- This hypothesis is based on observations and _____: A logical process that argues from specific instances to a general conclusion (making generalizations based on observations)

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The Logic of Hypothesis Testing

- Hypothesis testing is based on a process called _____: making predictions about the outcome of a test
 - Sometimes in “if ...then” statements
 - If vitamin C decreases the risk of catching a cold, then people who take vitamin C supplements with their regular diets will experience fewer colds than people who do not take supplements

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- ### The Logic of Hypothesis Testing
- Hypothesis rejected
 - Hypothesis supported (not proven)
 - Can't be 100% sure
 - Other factors (**alternative hypotheses**) could affect outcomes
 - Need to keep testing

- ### The Logic of Hypothesis Testing
- Even though we can't prove a hypothesis 100% true, we can gather enough evidence to determine whether a hypothesis is reasonably true

- ### The Experimental Method
- _____ are contrived situations designed to test specific hypotheses
 - Scientists can manipulate the environment, one _____ at a time
 - This helps the scientist to determine what specific variable is involved

- ### The Experimental Method
- _____ is collected as supporting evidence and is used to accept or reject the hypothesis

The Experimental Method

- The hypotheses scientists work with must be tested
- Past events – like dinosaur extinction – cannot be tested by experimentation
- Scientists use other methods such as examining fossils and carbon dating

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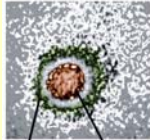
The Experimental Method

- Experimentation has led to the understanding that colds are caused by viruses
- Viruses are composed of
 - A small amount of genetic material
 - Some proteins
 - An outer protective coating

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Colds

Cold-causing virus



Protein shell
Genetic material and proteins

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- Scientific evidence has led to the understanding that colds are caused by viruses

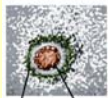
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The Experimental Method

- Viruses need to enter a cell to reproduce
- Viruses enter a cell and use the cell machinery to make more virus particles, which leave to infect more cells

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(a) Cold-causing virus



Protein shell
Genetic material and proteins

(b) How the virus causes a cold

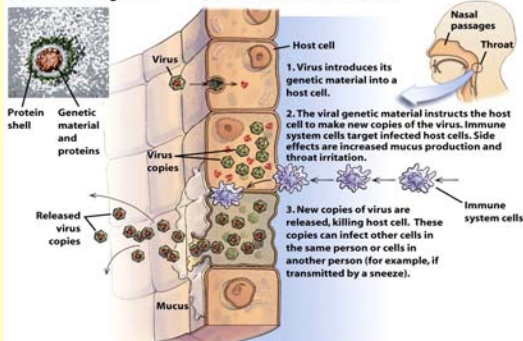


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The Experimental Method

- There are several hundred types of cold viruses
- They normally infect the cells of our noses and throats, causing the typical cold symptoms of sneezing, coughing, sore throat, and congestion

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The Experimental Method

- Viruses cause the common cold
- Scientists feel this statement is true because:
 1. There are no other reasonable supported hypotheses
 2. This hypothesis has not been rejected
 3. It conforms to a well-accepted scientific principle, the **germ theory**

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The Experimental Method

- A _____ is an explanation of a set of related observations based on well-supported hypotheses from several different, independent lines of research
- The germ theory arose from the accumulated observations of scientists such as Pasteur and Koch

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The Experimental Method

- “Truth” in science can be defined as:

What we know and understand based on all available information

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The Experimental Method

- If a hypothesis appears to explain all instances of a particular phenomenon and has been repeatedly tested and supported, it may eventually be accepted as accurate
- Even so, we do not say the hypothesis is proven true

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The Experimental Method

- If there is an abundance of evidence, then the idea may be referred to as a theory.
- What is a theory?
- In common speech, a theory is the same as a hypothesis – an untested idea

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The Experimental Method

- A *scientific* theory can explain how the natural world “works”...
- ...and is typically well-supported by observation and experiment

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The Experimental Method

- The **theory of evolution** states that all organisms derive from a single common ancestor and have changed and diverged through time

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The Experimental Method

- Darwin collected observations on the distribution of species, the distribution and appearance of fossils, similarities in form among organisms, and observations of change in traits of a species in response to human-caused selection
- Collectively these data along with those of other scientists form the theory of evolution which is the fundamental theory in biology

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Controlled Experiments

- Experiments are how scientists gain evidence to objectively support a hypothesis
 - Or fail to support a hypothesis
- To be sure that the experiment is unbiased, scientists use _____

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Controlled Experiments

- The _____ is the subject or group that is similar in every way to the experimental subject or group except that the control does not get the experimental treatment
- Controls can act as baseline measurements and are used to compare to the experimental group

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Controlled Experiments



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- Many people believe that colds can be treated with *Echinacea* to lessen the duration and severity of the cold symptoms

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Controlled Experiments

- One group drank tea which contained *Echinacea* extract
- A second group (the control group) drank tea which did not contain *Echinacea* extract
- The participants were asked to rate the effectiveness of the tea at reducing the cold symptoms

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Controlled Experiments

- The control group in this study was given a _____ – a tea that was missing the key ingredient for the study – *Echinacea* extract

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Controlled Experiments

- In this study, people who received echinacea tea felt that it was 33% more effective at reducing symptoms
- The “33% more effective” is in comparison to the opinions of people about the effectiveness of a tea that did not contain *Echinacea* extract— that is, the results from the control group

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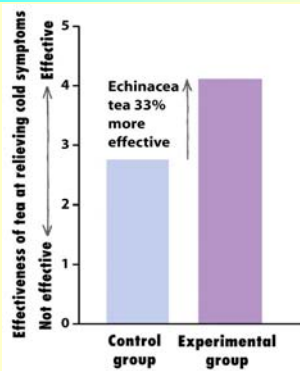


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Controlled Experiments

What does this mean?

- Since the only difference between the two groups was that the experimental group had *Echinacea* extract in their tea, that difference should account for the difference in results
- But was that the only difference?

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Controlled Experiments

Other possibilities: Were the participants all the same in...

- age?
- diet?
- stress level?
- how often they visited a health care provider?
- Do these matter? – Yes

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Controlled Experiments

- The only way to be sure that the experimental treatment causes the result is to have no other differences between the groups
 - If this is true, then you have a good controlled experiment

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Controlled Experiments

- One way to eliminate bias in groups is to randomly assign members to the control and experimental group ...
 - Like drawing names out of a hat
- _____ ensures that each groups is relatively balanced in characteristics

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Controlled Experiments

- In the *Echinacea* study all participants were female employees of a nursing home who sought relief from their colds at their employer's clinic
- As they entered the clinic, they were randomly assigned to either the control group or the experimental group

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Controlled Experiments

- Good controls are the basis of **strong inference**: a strong statement about the truth of a given hypothesis possible when an experimental protocol greatly minimizes the number of alternative hypotheses that can explain a result

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Controlled Experiments

- In the study, the data indicated that cold severity was lower in the experimental group compared to the placebo group
- The use of controls in the study allows researchers to have high confidence that they differed because *Echinacea* extract relieves cold symptoms
- A strong inference was possible

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Controlled Experiments

- Subjects in both groups should be treated exactly the same throughout the entire experiment, with the exception of the treatment being studied
- Notice that everything is the same except for the tea ingredient...

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Control group	Experimental group
Experiencing early cold symptoms	Experiencing early cold symptoms
Sought treatment from clinic	Sought treatment from clinic
Received placebo tea	Received echinacea tea



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Controlled Experiments

- One study alone usually isn't enough to convince the scientific community
- Many more studies of *Echinacea* were done: some supported the collected data, some conflicted with the collected data
- As of now, the use of *Echinacea* as a cold treatment is not scientifically supported, even though it continues to be commonly used

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Minimizing Bias in Experimental Design

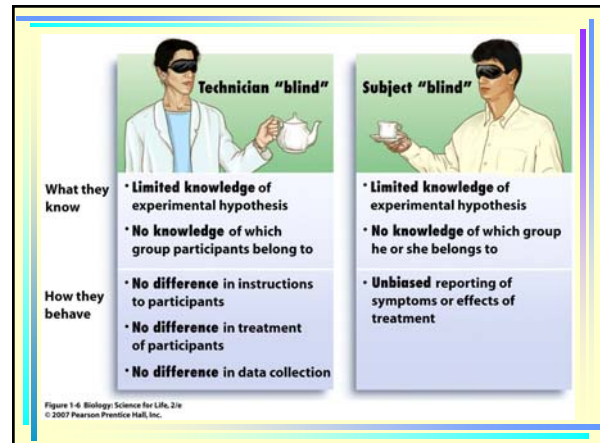
- Human influence from the researchers or their subjects may unfairly influence, or **bias**, an experiment's results
- Subjects may model behavior on what they think the researcher may expect
- A _____ avoids this by not letting the subjects know what experience is being predicted

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Minimizing Bias in Experimental Design

- A researcher making consistent errors in the measuring and evaluation of results is called _____
- Ensuring that the data are **objective** requires a lack of bias from the observer as well the observed
- In _____ experiments, both groups are unaware of either the hypothesis or whether the subjects are in the experimental group or the control group

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Using Correlation to Test Hypotheses

- Are true experiments, like the *Echinacea* study the best science?
- What if a placebo treatment would be unethical
 - Testing birth control pills
 - ✓ Treatment group gets pills
 - ✓ Control group gets placebo

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Using Correlation to Test Hypotheses

- Scientists can use model organisms
 - Mice, rats, Guinea pigs, dogs, monkeys
- This raises concerns over animal ethics

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Dog



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Using Correlation to Test Hypotheses

- For human studies, scientists can look at existing data and try to determine if there is a relationship, or _____, between the variables

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Using Correlation to Test Hypotheses

- Is there a relationship between stress levels and susceptibility to colds?
- Notice how the number of colds increases as stress levels increase...

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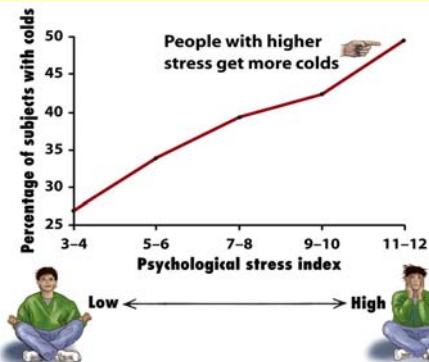


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Using Correlation to Test Hypotheses

- What does this mean?
- Do colds cause stress?
- Does stress cause colds?
- Correlation does not mean causation

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Or does one of the causes of high stress cause high cold frequency?

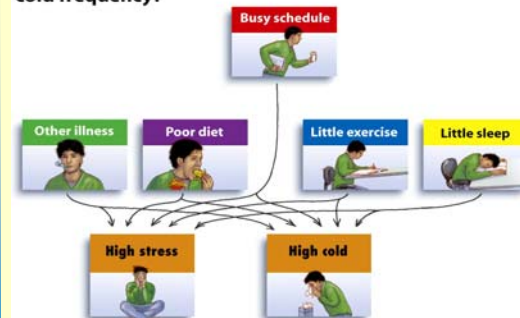


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Understanding Statistics

- Scientists use _____, a specialized branch of math, to determine significance of results
- Small groups, _____, are tested
- **Statistical tests** can be used to extend the results from a sample to the entire population

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Understanding Statistics

- If there is a difference, is that difference real or due to chance?
- The effect of chance on experimental results is known as _____
- If a result is _____, we know that there is a low probability that experimental groups differ simply by chance

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Understanding Statistics

- Many factors can influence the relationship between statistical significance, sample size, experimental tests, and hypotheses
- Statistics can't tell if an experiment was valid; statistics can only evaluate the data that was collected

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1.2 Evaluating Scientific Information

Peer Review:

- Once the experiment is concluded, the researchers can submit a paper to a professional journal

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Evaluating Scientific Information

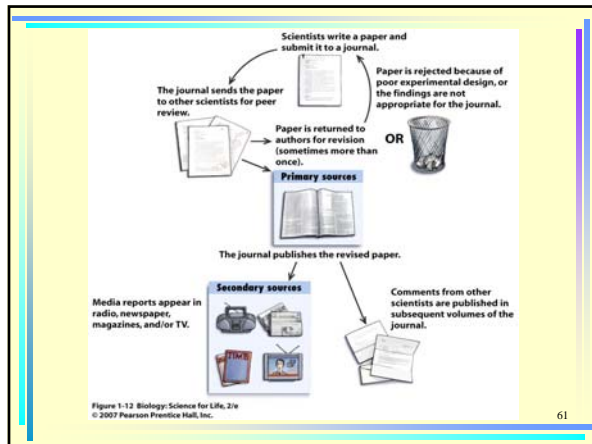
- The paper is reviewed by other researchers in the same field
- The paper is either rejected, returned for changes, or published in a _____

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Evaluating Scientific Information

- _____ bring published information to the public:
 - newspapers and magazines
 - television and radio
 - the internet

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Information from Anecdotes

- _____ is based on experience, not on experimental data
- Sometimes information in the media, that was based on a scientific study, is missing critical information or reports the information incorrectly

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Science in the News

- The internet is a source of scientific information, but be careful with it since anyone can post information
- Remember to use valid internet sites when looking for information on the internet
 - .gov, .edu, etc
- Ask yourself, “Where is the data?”

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Understanding Science from Secondary Sources

- As educated information consumers, you can use your understanding of the process of science and of experimental design to evaluate science stories published in secondary sources

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1.3 Is There a Cure for the Common Cold?

- There is not a cure yet, but prevention methods are known
- The best advice wash your hands
- Rates of common cold infections are 20% to 30% lower in populations employing effective hand-washing procedures

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