Don't fret, half of the packet is just reading resources!!

WHITE STATION

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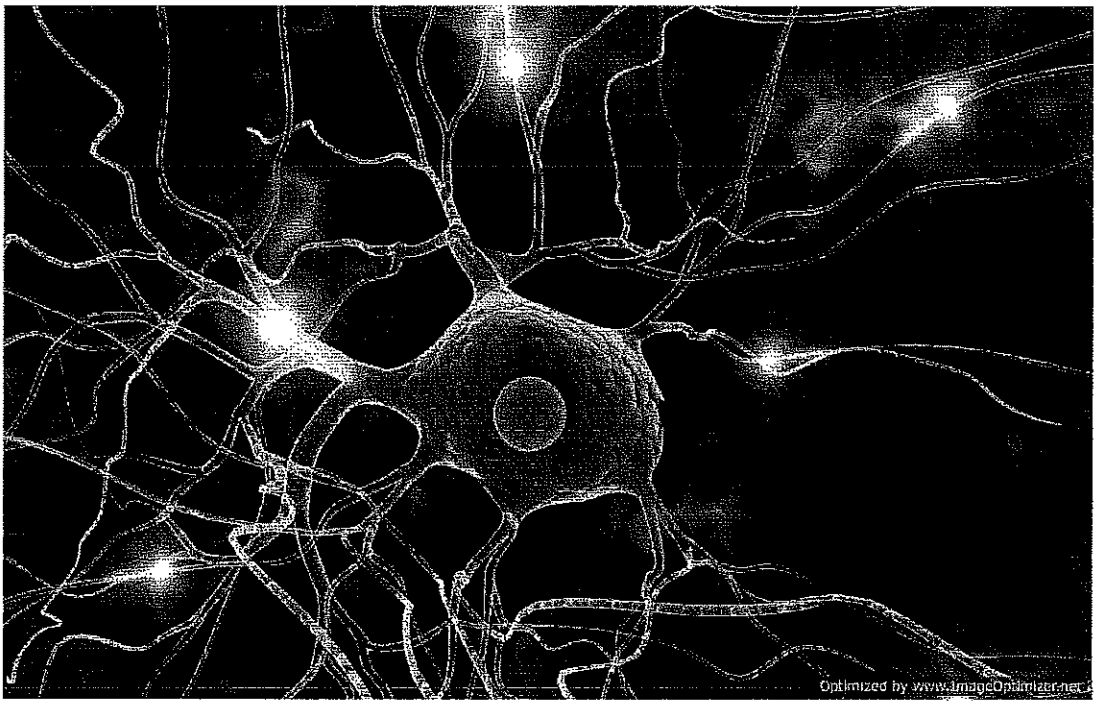
[redacted]



AP Biology Summer Assignment [redacted] 2021/22

Instructor: Chikezie O. Madu, Ph.D.

Text @wshapbio14 to (615)212-2686
To opt-out of messages at any time by replying,
"unsubscribe@wshapbo14"

33% of overall Lab grade

Heading

Full Name:

Grade:

Contact Phone Number:

Responses must be typed, scanned, and emailed to cemadu1@gmail.com

Deadline: 11:59 PM on 08/01/2021

******Hard copy will be turned in on the first day of the school year******

To contact instructor, email cemadu1@gmail.com. **Please do not call or text.**

Integrity Policy

"Plagiarism. Failure to acknowledge ideas, phrases, data, images, or other intellectual property gained from a preexisting body of work. This includes self-plagiarism, or the submission of one piece of work in more than one course without the explicit permission of the instructors involved."[1]

"Cooperative or collaborative effort in coursework without acknowledgment and explicit permission of the instructor. Assume that acknowledgement is necessary any time you collaborate and/or cooperate, unless you are expressly informed that it is not".[2]
"Cheating. The submission of work as one's own that has been prepared by another person."[3]

1-3-https://www.hamilton.edu/student-handbook/studentconduct/honor-code

"I affirm that I have not given or received any unauthorized help on this assignment, and that this work is my own."

Signature _____

This summer packet aims to address the Science Practices for AP Science Courses -

Science Practice 1: You should be able to use representations and models to communicate scientific phenomena and solve scientific problems.

1.1 You should be able to create representations and models of natural or man-made phenomena and systems in the domain

1.2 You should be able to describe representations and models of natural or man-made phenomena and systems in the domain

1.3 You should be able to refine representations and models of natural or man-made phenomena and systems in the domain

1.4 You should be able to use representations and models to analyze situations or solve problems qualitatively and quantitatively

1.5 You should be able to re-express key elements of natural phenomena across multiple representations in the domain.

Science Practice 2: You should be able to use mathematics appropriately

2.1 You should be able to justify the selection of a mathematical routine to solve problems

2.2 You should be able to apply mathematical routines to quantities that describe natural phenomena

2.3 You should be able to estimate numerically quantities that describe natural phenomena

Science Practice 3: You should be able to engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

3.1 You should be able to pose scientific questions

3.2 You should be able to refine scientific questions

3.3 You should be able to evaluate scientific questions

Science Practice 4: You should be able to plan and implement data collection strategies in relation to a particular scientific question.

4.1 You should be able to justify the selection of the kind of data needed to answer a particular scientific question.

4.2 You should be able to design a plan for collecting data to answer a particular scientific question

4.3 You should be able to collect data to answer a particular scientific question

4.4 You should be able to evaluate sources of data to answer a particular scientific question.

Science Practice 5: You should be able to perform data analysis and evaluation of evidence

5.1 You should be able to analyze data to identify patterns or relationships

5.2 You should be able to refine observations and measurements based on data analysis

5.3 You should be able to evaluate the evidence provided by data sets in relation to a particular scientific question

Science Practice 6: You should be able to work with scientific explanations and theories

6.1 You should be able to justify claims with evidence

6.2 You should be able to construct explanations of phenomena based on evidence produced through scientific practices

6.3 You should be able to articulate the reasons that scientific explanations and theories are refined or replaced

6.4 You should be able to make claims and predictions about natural phenomena based on scientific theories and models.

6.5 You should be able to evaluate alternative scientific explanations

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains

7.1 You should be able to connect phenomena and models across spatial and temporal scales

7.2 You should be able to connect concepts in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas

Dear AP Biology Students,
Welcome to AP Biology!

I am excited about working with you as you continue to expand your scientific understanding. Advanced Placement courses are reasonably arduous and AP Biology is no exception. We cover a two-semester college course in addition to a lab course. Occasionally, you will be asked to stretch yourself and some task will seem overwhelming. However, I will work with you to make it less stressful. While the course may be challenging, it will be worthwhile! Your summer assignment begins by:

First Task- ASAP due date 0[redacted]8 06/20/2021

1. Sign up for REMIND 101 **Text @wshapbio14 to (615)212-2686**
2. Check out the class website- The summer assignment will be located there along with all links.
https://sites.google.com/site/wshsbio/

06/24/24

Second Task- due date ~~06/01/18~~

Read chapter 1 and 2 of Campbell and Reece's *Biology 9th edition, AP edition textbook*. And pay attention to the objectives included in the packet. A copy of the textbook can be found on my webpage and the link can be accessed through the school web page Along with the assigned reading, you will be required to complete the guided reading and activities before August 1, 2016. You will take an assessment on this chapter and the entire packet the first Friday of the school year.

CHAPTER 1-INTRODUCTION: THEMES IN THE STUDY OF LIFE

After reading this chapter,

1. Briefly describe, in your own words, unifying themes that pervade the science of biology, and suggest why they are considered unifying themes.
2. Explain how the properties of life emerge from complex organization.
3. Describe five emergent properties associated with life, and suggest why they are essential.
4. Distinguish between holism and reductionism, using analogies.
5. Explain how technological breakthroughs contributed to the formulation of the cell theory and our current knowledge of the cell.
6. Using a Venn diagram, distinguish between prokaryotic and eukaryotic cells.
7. Explain, in your own words, what is meant by "form fits function." Describe five organs or cell that can be used to explain this.
8. List the five kingdoms of life and use a Venn diagram to compare and contrast them.
9. Distinguish between inductive and deductive reasoning using nonscientific and scientific examples.
10. Explain how science and technology are interdependent using several appropriate examples.

CHAPTER 2 THE CHEMICAL CONTEXT OF LIFE

After reading this chapter,

1. State four elements essential to life that make up 96% of living matter, and propose why they are essential.
2. Describe the structure of an atom and the importance the structure plays in its properties and function.
3. Explain how electron configuration influences the chemical behavior of an atom.
4. Define electronegativity and explain how it influences the formation of chemical bonds.
5. Distinguish among nonpolar covalent, polar covalent and ionic bonds using an analogy.
6. Describe the formation of a hydrogen bond and explain how it differs from a covalent or ionic bond.
7. Explain why weak bonds are important to living organisms and give an example of how it plays a role in life.
8. Describe how the relative concentrations of reactants and products affect a chemical reaction.

06/28/21

Third Task- due date [redacted]8

"Biological concepts and models are becoming more quantitative, and biological research has become critically dependent on concepts and methods drawn from other scientific disciplines. The connections between the biological sciences and the physical sciences, mathematics, and computer science are rapidly becoming deeper and more extensive." BIO2010 report of the National Research Council (2003)

Therefore, it is imperative that today's students develop and apply quantitative skills as part of their exploration into biology. A good grasp of quantitative methodology and reasoning is particularly important in the laboratory experience. Visit these websites and others you may find, and become familiar with the following statistic concepts:

1. Mean
2. Standard deviation
3. Standard error of mean
4. Chi square

https://www.youtube.com/watch?v=jgqYlSKoXak

http://www.bozemanscience.com/chi-squared-test/

http://www.bozemanscience.com/standard-deviation/

http://www.bozemanscience.com/standard-error/

You will take a quiz on this during the first week of school.

Fourth Task- due date 06/[redacted]/21

Article 1:

Does the Presence of Venomous Coral Snakes Affect Predation Rates on Their Mimics, Kingsnakes?

Introduction- The Article and Phenomenon Under Study

Many poisonous animals have warning coloration that signals to potential predators they are dangerous. Sometimes a harmless species, with warning coloration that mimics the dangerous species, benefits when predators confuse them with the harmful species. This phenomenon is called Batesian mimicry. Batesian mimicry should only be effective if predators have experience with the dangerous species. In order to test this mimicry hypothesis in nature, investigators designed field experiments with coral snakes and their mimics.

Article 2:

Can Diet Influence the Frequency of Birth Defects?

Introduction- The Article and Phenomenon Under Study

Birth defects that result from embryonic abnormalities in neural tube development include spina bifida and anencephaly. For decades, researchers have worked to understand possible causes of neural tube defects (NTDs), both genetic and environmental, and to develop health care practices to reduce their incidence. The British physician R.W. Smithells led pioneering work on possible prevention of NTDs by administration of vitamins to mothers around the time of conception.

Frequency-dependent Batesian mimicry

Predators avoid look-alikes of venomous snakes only when the real thing is around.

Batesian mimicry holds that palatable species look like dangerous species because both are then protected from predation[1–5]. But this protection should break down where the dangerous model is absent, when predators would not be under selection to recognize the model or any other species resembling it as dangerous[2,4,5]. Here we provide experimental evidence to support this critical prediction of Batesian mimicry by demonstrating that predators avoid harmless look-alikes of venomous coral snakes only in areas that are inhabited by these deadly snakes.

Many coral snakes and non-venomous kingsnakes possess red, yellow (or white), and black ringed markings[6], which predators avoid[7], though often without prior experience[8]. To determine whether this avoidance depends on the model's presence in the vicinity, we constructed snake replicas[7] (1.5 cm × 18 cm cylinders of pre-coloured, non-toxic plasticine threaded onto an S-shaped wire) with a tricolour ringed pattern, a striped pattern with identical colours and proportions as the ringed replicas, or a plain brown pattern.

Ringed replicas conformed to the local mimic: scarlet kingsnakes (*Lampropeltis triangulum elapsoides*), which resemble eastern coral snakes (*Micrurus fulvius*)[9], or sonoran mountain kingsnakes (*L. pyromelana*), which resemble western coral snakes *Micruroides euryxanthus*)[10]; striped and brown replicas served as controls. We arranged three different replicas (triplets) 2 m apart in natural habitat (each was used once only). At each site, 10 triplets were placed 75 m apart in a line. After collection, a person without knowledge of the replica's location scored attacks by noting any impressions corresponding to a predator[7].

We tested whether predators avoid *L. t. elapsoides* only in areas inhabited by *Micrurus* by placing 10 triplets at eight sympatric sites (sites with mimic and model) and eight allopatric sites (sites with only the mimic) in North and South Carolina, USA (480 replicas; allopatric sites were more than 80 km outside *Micrurus*'s range[9,11]; sites were 16–420 km apart). After 4 weeks, 25 (5.2%) replicas had been attacked by carnivores. The mean (± s.e.m.) proportion of ringed replicas attacked was significantly greater in allopatry (0.654 ± 0.107) than in sympatry (0.083 ± 0.116; $P = 0.009$, 2-tailed Wilcoxon two-group test).

We next investigated whether predators avoid *L. pyromelana* only in sympatry with *Micruroides* by placing 10 triplets at 24 sites (720 replicas) along an elevational gradient (1,204–2,866 m) near Portal, Arizona (*Micruroides* only occur at altitudes below 1,770 m (ref. 10); there were 14 sympatric and 10 allopatric sites 3–100 km apart). After 2 weeks, 49 (6.8%) replicas had been attacked by carnivores.

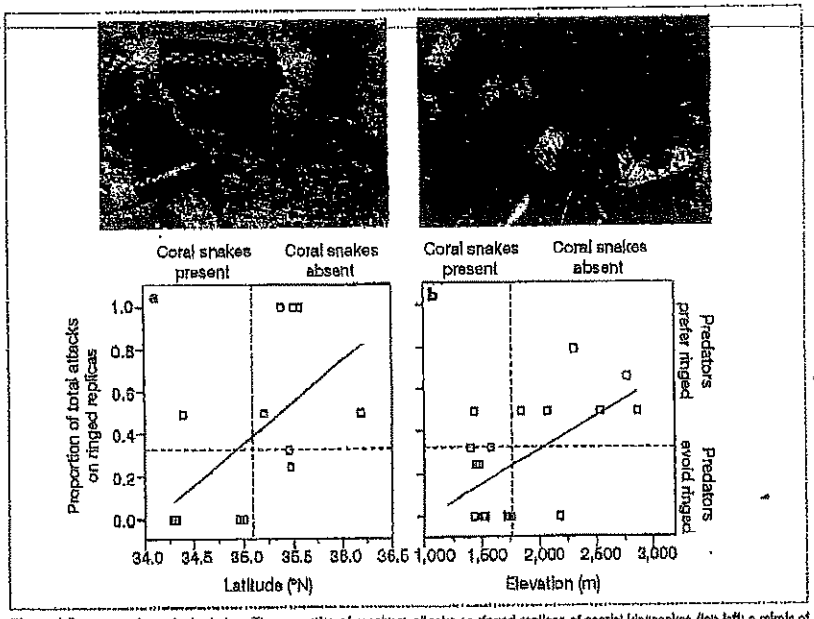


Figure 1 Frequency-dependent mimicry. The proportion of carnivore attacks on ringed replicas of scarlet kingsnakes (top left; a mimic of eastern coral snakes) and sonoran mountain kingsnakes (top right; a mimic of western coral snakes) increased with **a**, latitude ($y = -13.314 + 0.391x$, $P < 0.035$, $R^2 = 0.345$) and **b**, elevation ($y = -0.329 + 0.00032x$, $P < 0.014$, $R^2 = 0.310$). Horizontal dashed line: proportion of attacks on ringed replicas expected under randomness. Vertical dashed line: maximum latitude and elevation for coral snakes in North Carolina and Arizona, respectively.

The mean proportion of ringed replicas attacked was significantly greater in allopatry (0.496 ± 0.078) than in sympatry (0.138 ± 0.060; $P = 0.006$). Moreover, in sympatry, the proportion of ringed replicas attacked (0.138) was significantly less than randomness (0.33; $P = 0.010$, 2-tailed Wilcoxon signed-rank test). By contrast, attacks were random in allopatry ($P = 0.188$). Thus, predators avoid coral snake mimics only in sympatry with the model.

Coral snakes become increasingly rare with increasing latitude (Spearman $\rho = -0.57$, $P = 0.014$)[11] and elevation ($\rho = -0.77$, $P = 0.026$; our unpublished results). Consequently, selection to avoid ringed patterns should weaken with increasing latitude and elevation. As expected, the proportion of ringed replicas attacked increased gradually with latitude and elevation (Fig. 1), suggesting that selection to avoid ringed patterns is indeed sensitive to the abundance of coral snakes.

Our results do not fully resolve why mimetic patterns occur where models are absent[6,9–11]. Possibly selection for mimicry in sympatry, coupled with gene flow between sympatric and allopatric populations[12], maintains mimetic patterns in both regions. Nevertheless, our results verify the critical prediction of Batesian mimicry and demonstrate that the benefits of mimicry depend on abundance of the model.

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Guiding Questions for Reading This Article

A. About the Article

1. Give the name of the journal and the year in which this article was published.

2. What are the last names of the three authors? At what university was the work done?

3. Specialized vocabulary: Write a brief definition of each term.

   Defined in the article:

   Batesian mimicry

   Not defined in the article:

   sympatric

   allopatric

4. What type of organism is being studied? Give genus and species names, as well as common names, for two of the study species.

5. This study is designed to test what prediction of Batesian mimicry?

B. About the Study

6. From what materials did the investigators make the experimental models?

7. At each study site, investigators placed how many snake models of what three color patterns?

8. How many sympatric sites and how many allopatric sites were tested in North Carolina and South Carolina? How many sympatric sites and how many allopatric sites were tested in Arizona?

9. In Figure 1a, what is the *x*-axis? What is the *y*-axis? Which is the dependent variable? In Figure 1b, what is the *x*-axis and what is the *y*-axis?

10. What are the patterns of coral snake presence and absence by latitude and by elevation?

11. Hypothesis: Predators avoid Batesian mimics only in areas that are inhabited by the dangerous model.

    (a) Prediction (a) under this hypothesis: The proportion of total attacks on ringed replicas at *latitudes* where coral snakes are present will be _____ (higher? lower? no different?) than at latitudes where coral snakes do not occur.

    (b) Prediction (b) under this hypothesis: The proportion of total attacks on ringed replicas at *elevations* where coral snakes are present will be _____ (higher? lower? no different?) than at elevations where coral snakes do not occur.

12. Null hypothesis: There is no relationship between predator avoidance of Batesian mimics and presence of the dangerous model.

    (a) Prediction (a) under this null hypothesis: The proportion of total attacks on ringed replicas at *latitudes* where coral snakes are present will be _____ (higher? lower? no different?) than at latitudes where coral snakes do not occur.

(b) Prediction (b) under this null hypothesis: The proportion of total attacks on ringed replicas at *elevations* where coral snakes are present will be _____ (higher? lower? no different?) than at elevations where coral snakes do not occur.

13. In Figure 1a, look at the proportion of total attacks on ringed replicas placed at different latitudes in North Carolina and South Carolina. In which areas are the attack rates on ringed replicas higher: in areas where coral snakes are present or in areas where coral snakes are absent?

14. Do the results in Figure 1a (#13) agree with prediction (a) under the hypothesis?

15. Do the results in Figure 1a (#13) agree with prediction (a) under the null hypothesis?

16. The results in Figure 1a lead us to do which of these? (A) reject the hypothesis; (B) reject the null hypothesis.

17. In Figure 1b, look at the proportion of total attacks on ringed replicas placed at different elevations. In which areas are the attack rates on ringed replicas higher: in areas where coral snakes are present or in areas where coral snakes are absent?

18. Do the results in Figure 1b (#17) agree with prediction (b) under the hypothesis?

19. Do the results in Figure 1b (#17) agree with prediction (b) under the null hypothesis?

20. The results in Figure 1b lead us to do which one of these? (A) Reject the hypothesis; (B) reject the null hypothesis.

21. Is this an *observational study*, in which quantitative, observational data are taken but no experimental manipulation is made, or is this an *experimental study*, in which researchers make manipulations by which the effects of different variables are tested, one at a time?

22. Is this a *field study*, with data collected on organisms in their natural habitat, or is this a *lab study*, in which animals are studied under controlled conditions in the laboratory?

C. General Conclusions and Extensions of the Work

23. This system to measure predation on model snakes allows us to test specific predictions about Batesian mimicry. It is possible that other factors, besides the advantages of mimicry, explain the results observed. Perhaps it is simply the combination of bright red, yellow, and black colors on the snake replicas—not the ringed pattern itself—that explains the difference in attack rates. How could investigators test that possibility?

24. What if a particular milk snake subspecies is a poor mimic of the coral snake? Make a prediction: If this test is repeated in a geographic area where the milk snakes do not resemble coral snakes at all, would more ringed replicas be attacked?

25. Imagine that you were a member of this research team and involved in these experiments. What could be a possible follow-up test that extends this work? Briefly state another experiment or measurement you would do within this research system.

Preliminary Communication

POSSIBLE PREVENTION OF NEURAL-TUBE DEFECTS BY PERICONCEPTIONAL VITAMIN SUPPLEMENTATION

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R. HARRIS A. P. READ

Department of Medical Genetics, University of Manchester

D. W. FIELDING

Department of Pædiatrics, Chester Hospitals

Summary Women who had previously given birth to one or more infants with a neural-tube defect (NTD) were recruited into a trial of periconceptional multivitamin supplementation. 1 of 178 infants/fetuses of fully supplemented mothers (0·6%) had an NTD, compared with 13 of 260 infants/fetuses of unsupplemented mothers (5·0%).

INTRODUCTION

THE well-known social-class gradient in the incidence of neural-tube defects (NTD) suggests that nutritional factors might be involved in NTD ætiology. A possible link between folate deficiency and NTDs in man was first reported in 1965.[1] More recently, significant social-class differences in dietary intakes in the first trimester,[2] and in first-trimester values for red cell folate, leucocyte ascorbic acid, red-blood-cell riboflavin, and serum vitamin A have been reported,[3] dietary and biochemical values being higher in classes I and II than in classes III, IV, and V. Furthermore, 7 mothers, of whom 6 subsequently gave birth to NTD infants and 1 to an infant with unexplained microcephaly, had first-trimester mean values for red cell folate and leucocyte ascorbic acid that were significantly lower than those of controls.[3]

These observations are compatible with the hypothesis that subclinical deficiencies of one or more vitamins contribute to the causation of NTDs. We report preliminary results of an intervention study in which mothers at increased risk of having NTD infants were offered periconceptional multivitamin supplements.

PATIENTS AND METHODS

Women who had had one or more NTD infants, were planning a further pregnancy, but were not yet pregnant were admitted to the study. All women referred to the departments involved in the study and who met these criteria were invited to take part. Most patients were recruited from genetic counselling clinics, although some were referred by obstetricians and general practitioners informed of the study. Patients came from Northern Ireland, South-East England, Yorkshire, Lancashire, and Cheshire. 185 women who received full vitamin supplementation (see below) became pregnant.

The control group comprised women who had had one or more previous NTD infants but were either pregnant when referred to the study centres or declined to take part in the study. Some centres were able to select a control for each supplemented mother, matched for the number of previous NTD births, the estimated date of conception, and, where possible, age. There were 264 control mothers. The numbers of fully supplemented (S) and control (C) mothers in each centre were as follows: Northern Ireland S 37, C 122; South-East England S 70, C 70; Yorkshire S 38, C 35; Lancashire S 31, C 27; Cheshire S 9, C 10.

All mothers in supplemented and control groups were offered amniocentesis. 6 mothers in Northern Ireland (3 supplemented; 3 controls) declined amniocentesis and their pregnancies continue. They are not included in the figures above or in the accompanying table. All mothers with raised amniotic-fluid alpha-fetoprotein (AFP) values (1 supplemented; 11 controls) accepted termination of pregnancy.

Study mothers were given a multivitamin and iron preparation ('Pregnavite Forte F' Beecard), 1 tablet three times a day for not less than 28 days before conception and continuing at least until the date of the second missed period—i.e., until well after the time of neural-tube closure. Pregnavite forte F provides daily vitamin A 4000 I.U., vitamin D 400 I.U., thiamine 1·5 mg, riboflavin 1·5 mg, pyridoxine 1 mg, nicotinamide 15 mg, ascorbic acid 40 mg, folic acid 0·36 mg, ferrous sulphate equivalent to 75·6 mg Fe, and calcium phosphate 480 mg. Women conceiving less than 28 days after starting supplementation, or starting supplementation shortly after conception, or known to have missed tablets for more than 1 day, are regarded as partly supplemented. They were excluded from the main study and their results will be considered elsewhere.

In Northern Ireland, Yorkshire, and Cheshire women taking oral contraceptives (OCs) were asked to adopt alternative means of contraception from the date of starting vitamins because OCs may lower blood levels of certain vitamins.[4]

RESULTS

187 control mothers have delivered 192 infants (including 5 twin pairs) without NTDs, and a further 38 have normal amniotic-fluid AFP values (table). 13 mothers have been delivered of NTD infants/fetuses, 1

OUTCOME OF PREGNANCY IN FULLY SUPPLEMENTED AND CONTROL MOTHERS

	Fully supplemented	Controls
Infant/fetus with NTD	1	12
Infant without NTD	140(3)	192(5)
Subtotal (1)	141(3)	204(5)
Normal amniotic AFP	26	38
Subtotal (2)	167(3)	242(5)
Spontaneous abortions		
Examined, NTD	0	1
Examined, no NTD	11	17
Subtotal (3)	178(3)	260(5)
Not examined	10	9
Total	188(3)	269(5)

All numbers relate to infants/fetuses.
Figures in parentheses indicate numbers of twin pairs included.

by spontaneous abortion, 11 by termination after amniocentesis, and 1 by spontaneous delivery (skin-covered lesion, normal AFP). 17 fetuses of a further 26 control mothers who aborted spontaneously were examined and had no NTD. The provisional recurrence-rate of NTDs is 5·0% (13 in 260). 26 control mothers were at increased risk by virtue of having had 2 previous NTD infants. 3 of them had a further affected child, a recurrence-rate of 11·5%. Both these recurrence-rates are consistent with those previously reported and widely adopted in genetic counselling.

137 fully supplemented mothers have given birth to 140 babies (including 3 twin pairs) without NTD, 26 have normal amniotic-fluid AFP values and their pregnancies continue, and 1 has had a further affected infant. 11 fetuses of 21 mothers who aborted spontaneously were examined; none had an NTD. The provisional recurrence-rate in the supplemented group is therefore 0·6% (1 in 178). 15 supplemented mothers were at increased risk by virtue of having had 2 previous affected NTD infants. None had a further affected child.

Comparison of NTD frequencies in the supplemented and control groups by Fisher's exact test showed significant differences ($p<0·01$) for subtotals (1), (2), and (3) (table).

DISCUSSION

Despite problems with choosing controls, the control women in this study have shown recurrence-rates for NTDs entirely consistent with published data. By contrast the supplemented mothers had a significantly lower recurrence-rate. Possible interpretations of this observation include the following:

(1) *A group of women with a naturally low recurrence risk has unwittingly selected itself for supplementation.*—Apart from geographic and secular variations there is no evidence to suggest that any particular subgroup within populations, whether by social class or any other division, has a higher or lower recurrence risk. In genetic counselling clinics it is customary to quote the same risk for all mothers after one affected child. We cannot exclude the possibility that women who volunteered and cooperated in the trial might have had a reduced risk of recurrence of NTD. However, one might have expected such an effect to be found in mothers who cooperated in potato-avoidance trials, but this was not seen.[5]

(2) *Supplemented mothers aborted more NTD fetuses than did controls.*—The proportion of pregnancies ending in spontaneous abortion is similar in the two groups (supplemented 11·4%, control 9·6%). If the supplemented mothers have aborted more NTD fetuses, they must have aborted fewer other fetuses or had a lower initial risk of abortion. 11 of 21 abortuses of supplemented mothers have been examined and none had an NTD. 18 of 27 abortuses of control mothers were examined and 1 had an NTD. An explanation based on selective abortion of fetuses with NTD seems improbable, especially since more abortions are likely to have been ascertained in the supplemented group since controls were enrolled later in pregnancy.

(3) *Something other than vitamin supplementation has reduced the incidence of NTDs in the treated group.*—This is an almost untestable hypothesis, but if anything has reduced the incidence of NTDs it needs to be identified urgently. The only measure introduced by the study other than vitamin supplementation (and that only in some centres) was discontinuation of OCs at least 28 days before conception. Although the possibility of sex hormones having teratogenic action is not yet entirely resolved, evidence[6] strongly suggests that the phenomenon we report is not attributable to stopping OCs.

(4) *Vitamin supplementation has prevented some NTD.*—This is the most straightforward interpretation and is consistent with the circumstantial evidence linking nutrition with NTDs. If the vitamin tablets are directly responsible, we cannot tell from this study whether they operate via a nutritional or a placebo effect.

We hope that the data presented will encourage others to initiate similar and related studies. We intend to publish a more detailed report when the last of the present cohort of women receiving vitamin supplements has had her baby (due April 1980).

We thank the women taking part in this study; medical colleagues who referred them; and Dr Jennifer Hanna; Miss Wendy Johnston, Mrs Monica Stant and Mrs Mary Weetman (health visitors). This study is supported by Action Research for the Crippled Child, the Children's Research Fund, and Beecham Pharmaceuticals Ltd.

Requests for reprints should be addressed to R. W. S., Department of Pediatrics and Child Health, University of Leeds, 27 Blundell Street, Leeds LS1 3ET.

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5. Nevin NC, Merrett JD. Potato avoidance during pregnancy in women with a previous infant with either anencephaly and/or spina bifida. *Br J Prev Soc Med* 1975; 29: 111–15.
6. Rothman KJ, Louik C. Oral contraceptives and birth defects. *N Engl J Med* 1978; 299: 522–24.

Guiding Questions for Reading This Article

A. About the Article

1. Give the name of the journal and the year in which this article was published.

2. State the last name of the first author, his department, and his university.

3. Specialized vocabulary: Write a brief definition of each term.

   amniocentesis

   neural tube defects (NTDs)

   periconceptional

   placebo

   vitamin

B. About the Study

4. The authors point out that the observed higher incidence of NTDs in lower social classes as compared to higher social classes might be due to what factors?

5. What criteria were used to select women for this study?

6. The control group consisted of whom?

7. How many mothers were in the fully supplemented group, and what was their treatment?

8. How did investigators treat data on women who conceived before taking the supplements for a month and those who missed some of the supplements?

9. In controlled experiments in general, the experimental group and the control group are alike in all factors except in the one being tested. In this study, the test factor is the nutritional supplement. (a) Some study centers used paired controls, in which a supplemented mother was paired for comparison with a control mother. What criteria were used for matching the pairs? (b) In this study, what are some other ways the supplemented mothers and the control mothers might have differed, besides whether or not they received the supplement?

10. From the table showing outcome of pregnancy in fully supplemented and control mothers, what is the difference in number of NTD infants between the supplemented and control groups? What was the difference in percentage of NTDs in the two groups of women?

11. The authors state that their data agree with the hypothesis that vitamin supplementation during the period around conception is associated with lower incidence of NTDs. In their Discussion section, they mention three alternative explanations for this association. Briefly list the three explanations in your own words.

C. General Conclusions and Extensions of the Work

12. Do you think the observed difference is significant enough to conclude that vitamin supplementation has prevented some NTDs in women who have previously had NTD infants? Do you think the results can be generalized to conclude that vitamin supplementation will prevent NTDs in all women? Why or why not?

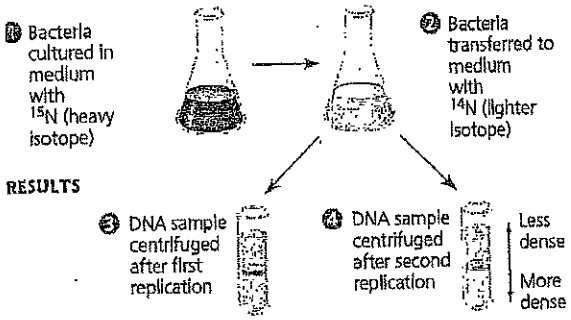
13. In 1983, B. Lipsett and J. C. Fletcher published a paper entitled "Do vitamins prevent neural tube defects (and can we find out ethically)?" in the *Hastings Center Report* (13:508). They documented the early history of R. W. Smithells's work on multivitamins and birth defects, including the paper in this exercise. They pointed out that, before beginning his studies in 1976, Smithells had requested approval from several ethics committees to do a "randomized, placebo-controlled" clinical trial, but his requests were refused. (a) How would the study procedures be different if trials were "randomized"? (b) What is a "placebo"? How would the study procedures be different with the use of placebos? (c) Why do you think the ethics committees denied Smithells's request? Do you think they should have approved the research request?

14. Imagine that you were a member of this research team and involved in these investigations. What could be a possible follow-up test that extends this work?

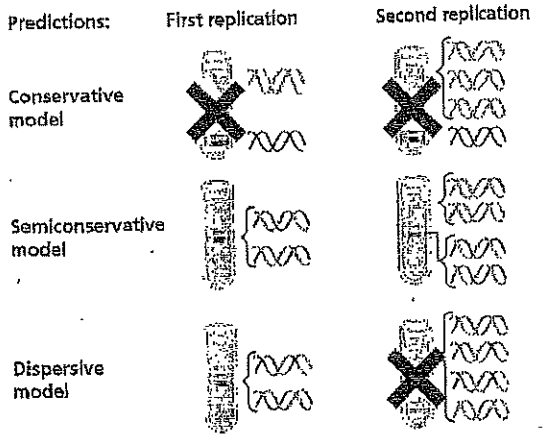
▼ Figure 16.11 **INQUIRY**

Does DNA replication follow the conservative, semiconservative, or dispersive model?

EXPERIMENT At the California Institute of Technology, Matthew Meselson and Franklin Stahl cultured *E. coli* for several generations in a medium containing nucleotide precursors labeled with a heavy isotope of nitrogen, ^{15}N. They then transferred the bacteria to a medium with only ^{14}N, a lighter isotope. A sample was taken after DNA replicated once; another sample was taken after DNA replicated again. They extracted DNA from the bacteria in the samples and then centrifuged each DNA sample to separate DNA of different densities.



CONCLUSION Meselson and Stahl compared their results to those predicted by each of the three models in Figure 16.10, as shown below. The first replication in the ^{14}N medium produced a band of hybrid (^{15}N-^{14}N) DNA. This result eliminated the conservative model. The second replication produced both light and hybrid DNA, a result that refuted the dispersive model and supported the semiconservative model. They therefore concluded that DNA replication is semiconservative.



SOURCE M. Meselson and F. W. Stahl, The replication of DNA in *Escherichia coli*, *Proceedings of the National Academy of Sciences USA* 44:671–682 (1958).

INQUIRY IN ACTION Read and analyze the original paper in *Inquiry in Action: Interpreting Scientific Papers.*

MS See the related Experimental Inquiry Tutorial in MasteringBiology.

MUTATE IT If Meselson and Stahl had first grown the cells in ^{14}N-containing medium and then moved them into ^{15}N-containing medium before taking samples, what would have been the result?

Analyzing a Journal Article

1. Describe the purpose of the study (as you understand it) in your own words.

2. What was the "gap" in the research that the authors were trying to fill by doing their study?

3. Make some notes about the authors' major conclusions or findings as you understand them

4. How did the authors analyze their data? What test/s did they use?

5. Do the authors suggest any problems with the study that could lead to unreliable results?

6. Was there anything that was left unfinished? Did the author raise questions or make points that were left orphaned in the paper?

7. Write (in your own words) the significant contributions of the experimental work in this journal article as reported by the authors.

8. What are three implications of the result?

9. What future study can you conduct from this study?

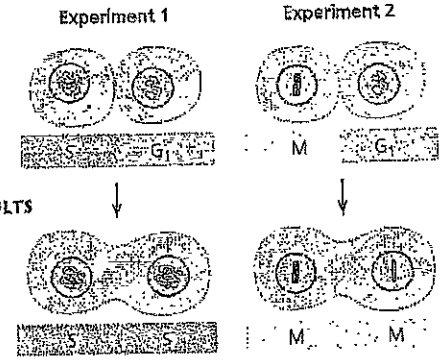
10. State three questions you can generate from this study

11. State two questions you can generate from the conclusion

Figure 12.14 **INQUIRY**

Do molecular signals in the cytoplasm regulate the cell cycle?

EXPERIMENT Researchers at the University of Colorado wondered whether a cell's progression through the cell cycle is controlled by cytoplasmic molecules. To investigate this, they selected cultured mammalian cells that were at different phases of the cell cycle and induced them to fuse. Two such experiments are shown here.



When a cell in the S phase was fused with a cell in G_1, the G_1 nucleus immediately entered the S phase—DNA was synthesized.

When a cell in the M phase was fused with a cell in G_1, the G_1 nucleus immediately began mitosis—a spindle formed and the chromosomes condensed, even though the chromosomes had not been duplicated.

CONCLUSION The results of fusing a G_1 cell with a cell in the S or M phase of the cell cycle suggest that molecules present in the cytoplasm during the S or M phase control the progression to those phases.

SOURCE R. T. Johnson and P. N. Rao, Mammalian cell fusion: induction of premature chromosome condensation in interphase nuclei, *Nature* 226:717–722 (1970).

WHAT IF? If the progression of phases did not depend on cytoplasmic molecules and each phase began when the previous one was complete, how would the results have differed?

a single cell with two nuclei. If one of the original cells was in the S phase and the other was in G_1, the G_1 nucleus immediately entered the S phase, as though stimulated by signaling molecules present in the cytoplasm of the first cell. Similarly, if a cell undergoing mitosis (M phase) was fused with another cell in any stage of its cell cycle, even G_1, the second nucleus immediately entered mitosis, with condensation of the chromatin and formation of a mitotic spindle (**Figure 12.14**).

The Cell Cycle Control System

The experiment shown in Figure 12.14 and other experiments on animal cells and yeasts demonstrated that the sequential events of the cell cycle are directed by a distinct **cell cycle control system**, a cyclically operating set of molecules in the cell that both triggers and coordinates key events

Analyzing a Journal Article

1. Describe the purpose of the study (as you understand it) in your own words.
2. What was the "gap" in the research that the authors were trying to fill by doing their study?
3. Make some notes about the authors' major conclusions or findings as you understand them
4. How did the authors analyze their data? What test/s did they use?
5. Do the authors suggest any problems with the study that could lead to unreliable results?
6. Was there anything that was left unfinished? Did the author raise questions or make points that were left orphaned in the paper?
7. Write (in your own words) the significant contributions of the experimental work in this journal article as reported by the authors.
8. What are three implications of the result?
9. What future study can you conduct from this study?
10. State three questions you can generat. . from this study
11. State two questions you can generat. · from the conclusion

Analyzing a Journal Article

1. Describe the purpose of the study (as you understand it) in your own words.

2. What was the "gap" in the research that the authors were trying to fill by doing their study?

3. Make some notes about the authors' major conclusions or findings as you understand them

4. How did the authors analyze their data? What test/s did they use?

5. Do the authors suggest any problems with the study that could lead to unreliable results?

6. Was there anything that was left unfinished? Did the author raise questions or make points that were left orphaned in the paper?

7. Write (in your own words) the significant contributions of the experimental work in this journal article as reported by the authors.

8. What are three implications of the result?

9. What future study can you conduct from this study?

10. State three questions you can generat from this study

11. State two questions you can generat from the conclusion

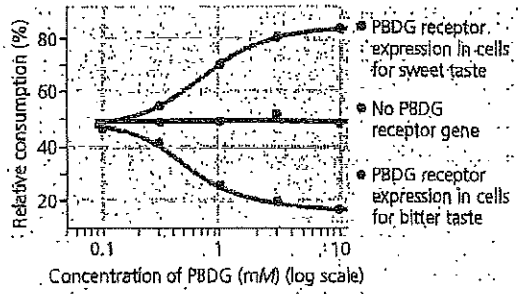
▼ Figure 50.23 **INQUIRY**

How do mammals detect different tastes?

EXPERIMENT To investigate the basis of mammalian taste perception, Ken Mueller, Nick Ryba, and Charles Zuker used a chemical called phenyl-β-D-glucopyranoside (PBDG). Humans find the taste of PBDG extremely bitter. Mice, however, appear to lack a receptor for PBDG. Whereas mice avoid drinking water containing other bitter tastants, they show no aversion to water that contains PBDG.

Using a molecular cloning strategy, Mueller generated mice that made the human PBDG receptor in cells that normally make either a sweet receptor or a bitter receptor. The mice were given a choice of two bottles, one filled with pure water and one filled with water containing PBDG at varying concentrations. The researchers then observed whether the mice had an attraction or an aversion to PBDG.

RESULTS



Relative consumption = (Fluid intake from bottle containing PBDG ÷ Total fluid intake) × 100%

CONCLUSION The researchers found that the presence of a bitter receptor in sweet taste cells is sufficient to cause mice to be attracted to a bitter chemical. They concluded that the mammalian brain must therefore perceive sweet or bitter taste solely on the basis of which sensory neurons are activated.

SOURCE K. L. Mueller et al., The receptors and coding logic for bitter taste, *Nature* 434:225–229 (2005).

WHAT IF? Suppose instead of the PBDG receptor the researchers had used a receptor specific for a sweetener that humans crave but mice ignore. How would the results of the experiment have differed?

reprogram gustation in a mouse (**Figure 50.23**). Based on these and other studies, the researchers concluded that an individual taste cell expresses a single receptor type and detects tastants representing only one of the five tastes.

The receptor cells for taste in mammals are modified epithelial cells organized into **taste buds**, which are scattered in several areas of the tongue and mouth (**Figure 50.24**). Most taste buds on the tongue are associated with nipple-shaped projections called papillae. Any region of the tongue with taste buds can detect any of the five types of taste. (The frequently reproduced "taste maps" of the tongue are thus not accurate.)

Taste receptors fall into two categories, each evolutionarily related to receptors for other senses. The sensation of sweet,

Analyzing a Journal Article

1. Describe the purpose of the study (as you understand it) in your own words.

2. What was the "gap" in the research that the authors were trying to fill by doing their study?

3. Make some notes about the authors' major conclusions or findings as you understand them

4. How did the authors analyze their data? What test/s did they use?

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6. Was there anything that was left unfinished? Did the author raise questions or make points that were left orphaned in the paper?

7. Write (in your own words) the significant contributions of the experimental work in this journal article as reported by the authors.

8. What are three implications of the result?

9. What future study can you conduct from this study?

10. State three questions you can generat · ·rom this study

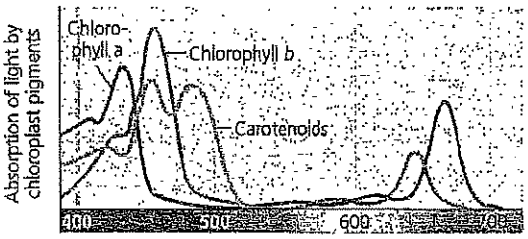
11. State two questions you can generat · · from the conclusion

Figure 10.10 **INQUIRY**

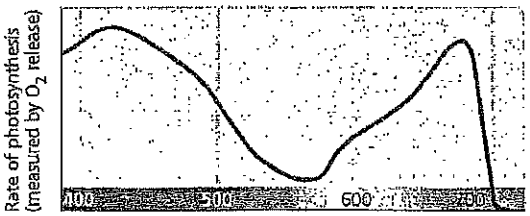
Which wavelengths of light are most effective in driving photosynthesis?

EXPERIMENT Absorption and action spectra, along with a classic ex periment by Theodor W. Engelmann, reveal which wavelengths of ligh are photosynthetically important.

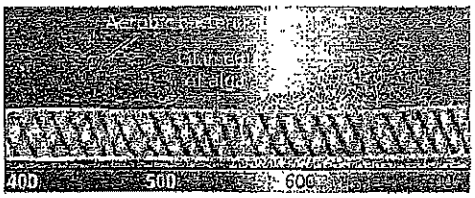
RESULTS



(a) **Absorption spectra.** The three curves show the wavelengths of ligh best absorbed by three types of chloroplast pigments.



(b) **Action spectrum.** This graph plots the rate of photosynthesis versus wavelength. The resulting action spectrum resembles the absorption spectrum for chlorophyll *a* but does not match exactly (see part a). This is partly due to the absorption of light by accesson pigments such as chlorophyll *b* and carotenoids.



(c) **Engelmann's experiment.** In 1883, Theodor W. Engelmann illuminated a filamentous alga with light that had been passed through a prism, exposing different segments of the alga to differen wavelengths. He used aerobic bacteria, which concentrate near an oxygen source, to determine which segments of the alga were releasing the most O_2 and thus photosynthesizing most. Bacteria congregated in greatest numbers around the parts of the alga illuminated with violet-blue or red light.

CONCLUSION Light in the violet-blue and red portions of the spec trum is most effective in driving photosynthesis.

SOURCE T. W. Engelmann, *Bacterium photometricum*, Ein Betrag zur ver gleichenden Physiologie des Licht- und farbensinnes, *Archiv. für Physiologie* 30:95–124 (1883).

See the related Experimental Inquiry Tutorial in MasteringBiology.

WHAT IF? If Engelmann had used a filter that allowed only red light to pass through, how would the results have differed?

Analyzing a Journal Article

1. Describe the purpose of the study (as you understand it) in your own words.

2. What was the "gap" in the research that the authors were trying to fill by doing their study?

3. Make some notes about the authors' major conclusions or findings as you understand them

4. How did the authors analyze their data? What test/s did they use?

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8. What are three implications of the result?

9. What future study can you conduct from this study?

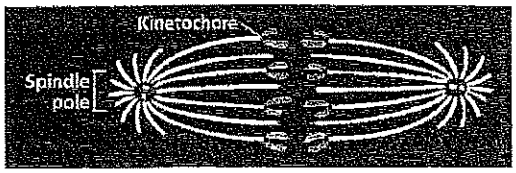
10. State three questions you can generat from this study

11. State two questions you can generat from the conclusion

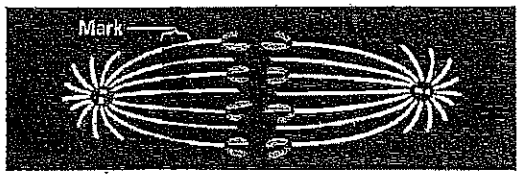
▼ Figure 12.9 **INQUIRY**

At which end do kinetochore microtubules shorten during anaphase?

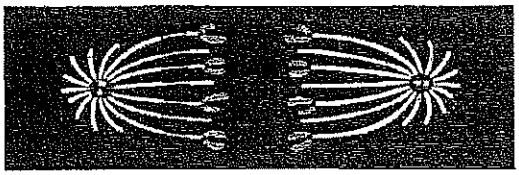
EXPERIMENT Gary Borisy and colleagues at the University of Wiscons wanted to determine whether kinetochore microtubules depolymerize the kinetochore end or the pole end as chromosomes move toward tl poles during mitosis. First they labeled the microtubules of a pig kidn cell in early anaphase with a yellow fluorescent dye.



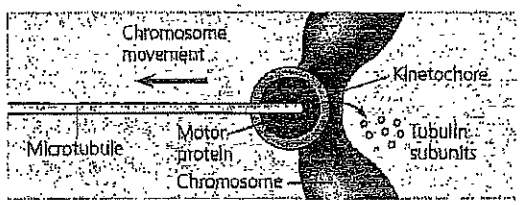
Then they marked a region of the kinetochore microtubules betwe one spindle pole and the chromosomes by using a laser to eliminate tl fluorescence from that region, while leaving the microtubules inta (see below). As anaphase proceeded, they monitored the changes microtubule length on either side of the mark.



RESULTS As the chromosomes moved poleward, the microtubule se ments on the kinetochore side of the mark shortened, while those c the spindle pole side stayed the same length.



CONCLUSION During anaphase in this cell type, chromosome mov ment is correlated with kinetochore microtubules shortening at the kinetochore ends and not at their spindle pole ends. This experimer supports the hypothesis that during anaphase, a chromosome is walke along a microtubule as the microtubule depolymerizes at its kinet chore end, releasing tubulin subunits.



SOURCE G. J. Gorbsky, P. J. Sammak, and G. G. Borisy, Chromosome move poleward in anaphase along stationary microtubules that coord nately disassemble from their kinetochore ends, *Journal of Cell Biolog* 104:9–18 (1987).

WHAT IF? If this experiment had been done on a cell type in whic "reeling in" at the poles was the main cause of chromosome move ment, how would the mark have moved relative to the poles? Hov would the microtubule lengths have changed?

Academic Honesty

A. High integrity and academic honesty is expected. Students should not do anything that would bring their integrity into question.

B. All assessments (homework, labs, quizzes, exams, projects, etc.) are expected to be completed only by the student.

C. Students MUST consult with instructor before using ANY internet site to study for a quiz, test or exam. This includes, but not limited to, sites like QUIZLET©

D. Collaboration and teamwork may be allowed on homework **with prior approval from instructor**; however, individual work must always be distinctly original from the lab partners' work or zero credit will be earned.

E. ALL papers must be emailed to the instructor and second copy turned in as a hard copy.

F. Always properly cite and credit sources that are not your own (text, data, pictures, etc.).

G. Copying work, full or in part, is in violation of the academic honesty policies and students sharing testing information between classes are also in violation of the academic honesty policy.

H. DISHONESTY is not tolerated and may result in a "0" on that test/assignment, a referral, and removal from the Honor Society (and/or equivalent school organizations), contact to home and possibly further disciplinary measures as per school/district policies.

I. Students copying and students allowing others to copy their work are both academically dishonest. Do not put your classmates in an uncomfortable position by asking to copy.

J. Instructor reserves the right to modify or add new directives to this, either verbally in class of in writing without prior notice to students.

K. Students will write the following statement on every assignment, test, or project turned in:

Pledge

❖ *On my honor, I have neither given nor received unauthorized aid on this assignment.*[1]

Please read and sign below the following

"I pledge to maintain a high level of respect and integrity as a student representing White station High School. I understand and will uphold the Honor Code in letter and spirit to help our school advance authentic learning. I will not lie, cheat, plagiarize or be complicit with those who do. I will encourage fellow students who commit honor offenses to acknowledge such offenses to their teacher. I make this pledge in the spirit of honor and trust."[2]

Student Signature

1. River Hill High School, Clarksville, MD – Public – http://www.howard.k12.md.us/rhhs/honor/honorcouncil2.htm
2. http://www.ethicsed.org/programs/integrity-works/pdf/HonorPledgeExamples.pdf

CLASS MATERIALS

For the classroom

1. **$40 lab supplies-essential**

   or

   All of the following-

2. $25 lab supplies-**essential**
3. Two dry erase markers- dark colors
4. 2 reams of copying paper
5. 1 pack of batteries(4 in a pack)
   a) AA (**girls only**)
   b) AAA (**boys only**)
6. Lab gloves-
   a) last names A-H- (small)
   b) last names I-M- (medium)
   c) last names N-S- (large)
   d) last names with T-Z- (extra-large)
7. 2 rolls of paper towel
8. 1 gallon of distilled water
9. 1 pack of red pens

Donations (thank you)

1. Large box of tissue
2. Sanitizing wipes for desks

For students to keep

Microsoft Office© applications will be the primary software applications used. Adequate computer resources are available in the classroom as well as throughout the school.

Fifth Task- due date 06/25/16

CONSTRUCTING LINE GRAPHS*

Suppose we are studying some chemical reaction in which a substance, *A*, is being used up. We begin with a large quantity (100 mg) of *A*, and we measure in some way how much *A* is left after different times. The results of such an experiment might be presented pictorially like this:

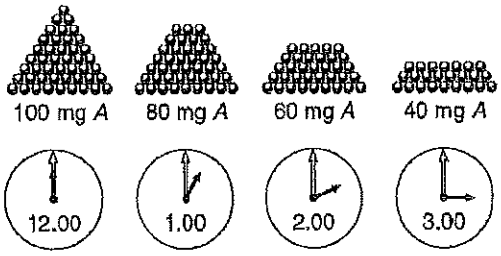


Figure A.1

This is the kind of picture graph that you often see in newspapers. This information can be presented much more simply on a graph — a line graph is permissible — because our experience tells us that when *A* is disappearing in a chemical reaction, it is disappearing more or less smoothly and will not suddenly reappear. In other words, the progress of a chemical reaction is a continuous process, and because time is a continuous process it is permissible to relate the two kinds of information to one another on a line graph. The procedure for constructing the line graph is shown in Figure A.2.

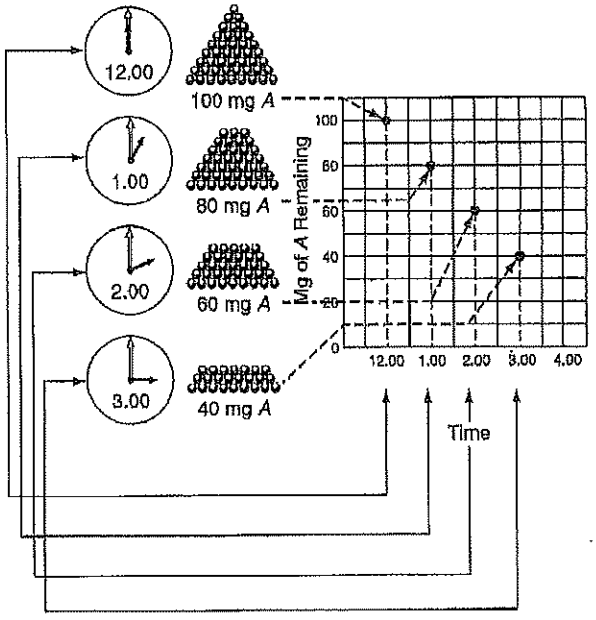


Figure A.2

* Based on a handout by Dr. Mary Stiller, Purdue University.

It should be clear from the diagram that each point corresponds both to a particular measurement of the amount of *A* remaining and to the particular time at which that amount remained. (A heavy dot is made opposite both of these two related quantities.) When all the measurements have been recorded in this way, we connect the dots with a line, shown in Figure A.3. (Figures A.21–A.23 explain when to connect the data points.)

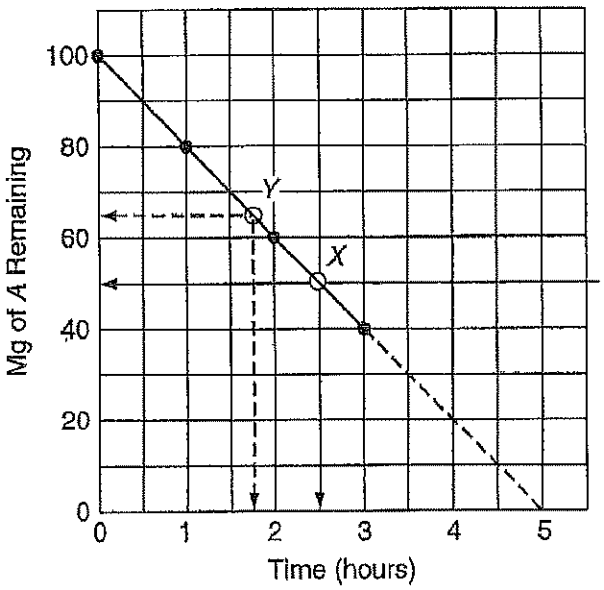


Figure A.3

It should be clear by looking at our graph that the only measurements we actually made are those indicated by the dots. However, because the information on both scales of the graph is assumed to be continuous, we can use the graph to find out how much *A* would have been found if we had made our measurements at some other time, say 2.5 hours. We merely locate the line that corresponds to 2.5 hours on our time scale and follow it up until it crosses our line graph at the point X; then we look opposite X to the "Mg of *A* Remaining" scale, and read off 50 mg. We conclude, then, that if we had made a measurement at 2.5 hours, we would have found 50 mg of *A* left. In a similar way, we can find out from our graph at what time a given amount of *A*, say 65 mg, would be left. We have merely to find the line that represents 65 mg on the vertical scale and follow it across until it cuts the line graph at point Y. Then we see 1.75 hours on the "Time" scale opposite Y. This tells us that had we wished to stop the reaction with 65 mg of *A* remaining, we would have had to do so after 1.75 hours.

You will notice that part of the graph has been drawn with a broken line. In making a line graph we are properly allowed to connect only the points representing our actual measurements. It is possible that measurements made after 3 hours will give points that will fall on the broken-line extension of the graph, but this is not necessarily so. In fact, the reaction may begin to slow up perceptibly, so that much less *A* is used up in the fourth hour than in the third hour. Not having made any measurements during the fourth hour, we cannot tell, and we confess our ignorance quite openly by means of the broken line. The broken line portion of the graph is called an **extrapolation**, because it goes beyond our actual experience with this particular reaction. Between any two of our

measured points it seems fairly safe to assume that the reaction is proceeding steadily, and this is called an **interpolation**. Interpolations can only be made between measured points on a graph; beyond the measured points we must extrapolate. We know that the amount of *A* remaining after 4 hours is somewhere between 0 and 40 mg. The amount indicated by the broken line on the graph, 20 mg, is only a logical guess.

Unfortunately, it sometimes happens that even professionals take this sort of limitation of line graphs for granted and do not confess, by means of a broken line, the places where they are just guessing. Therefore, it is up to readers of the graph to notice where the last actual measurement was made and use their own judgment about the extrapolated part. Perhaps the extrapolated part fits quite well with the reader's own experience of this or a similar reaction, and he or she is quite willing to go along with the author's extrapolation. On the other hand, the reader may be interested only in the early part of the graph and be indifferent to what the author does with the rest of it. It may also be that the reader knows that the graph begins to flatten out after 3 hours and so disagrees with the author. The point is that we, the readers, must be aware of what part of the graph is extrapolated, that is, predicted, from the shape of the graph up to the time when the measurements were stopped. Hence, you must clearly indicate on a line graph the points that you actually measured. Regardless of what predictions or conclusions you want to make about the graph, you *must* give the reader the liberty of disagreeing with you. Therefore, it is very improper to construct a line graph consisting of an unbroken line without indicating the experimentally determined points.

BASIC REQUIREMENTS FOR A GOOD GRAPH

The following procedure applies primarily to graphs of experimental data that are going to be presented for critical evaluation. It does not apply to the kind of rough sketch that we often use for purposes of illustration.

Every graph presented for serious consideration should have a good **title** that tells what the graph is about. Notice that we need more than just a title; we need a *good* title. Before we try to make a good title, let us look at an example and try to decide what kind of title is a useful one. Look at Figure A.4.

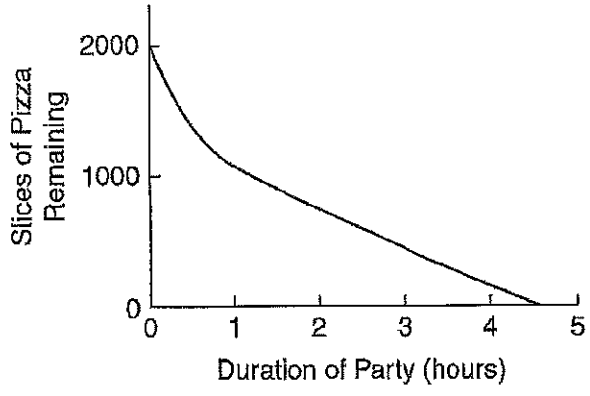


Figure A.4

If you like pizza, it might be very useful to know when this party is being held. Without a title, you cannot tell even whether the graph refers to any particular party at all. It

might represent average figures for all the parties held last year, or it might represent the expected figures for a party that is going to be held tonight. Let us suppose that these data refer to a study party given by AP Biology students on March 9. Here, then, are some possible titles:

(a) The APs Have a Party

(b) Pizza Rules! Enjoy it with AP

(c) An AP Biofeast!

None of those titles is especially useful or informative because none of them tells what the graph is all about. Now look at these two titles:

(d) Anticipated Consumption of Slices of Pizza at the AP Biology Party, March 9

(e) Anticipated Consumption of Slices of Pizza at the AP Biology Party, March 9, 2011, 7:00 p.m.–11:00 p.m.

You should be able to see that only title (e) is helpful and useful. It enables you to tell, by glancing at the calendar, whether or not you can attend the party, and it helps make that graph fall a little more steeply. The point we are driving at is that a *good* title is one that tells exactly what information the author is trying to present with the graph. Although brevity is desirable, it should not substitute for completeness and clarity.

Now that you are clear on titles, look at the graph in Figure A.5. Its title tells you that here is some potentially useful information. The graph suggests that, at least for 2011, there was an upper limit to the amount of time people could usefully spend in studying for an exam, and you might wonder, for example, how long you would have had to study to make a perfect score.

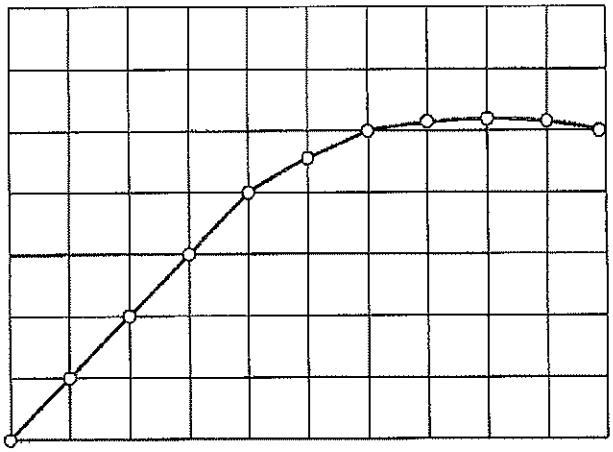


Figure A.5: Relation Between Study Time and Score on a Biology Exam in 2011

Unfortunately, however, you cannot tell, because the graph has no labels of numbers or units the scales. Even though this graph has a descriptive and intriguing title, it is of no use to us at all without these very important parts. Obviously, before we can take full advantage of the information that the graph is trying to present, we need to have some additional details.

In Figure A.6 the additional information has been supplied, information that seems to make the graph more useful to us in preparing for the exam.

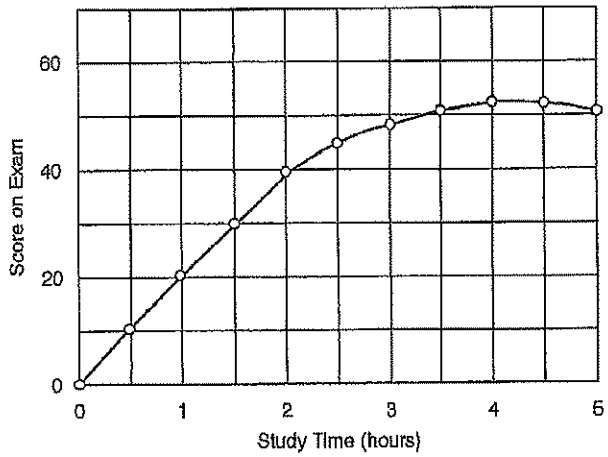


Figure A.6: Relation Between Study Time and Score on a Biology Exam in 2011

This additional information includes scales, or **axes**, that are carefully marked with numbers, and labels and units that are neatly presented. Obviously, one cannot label all the points along the axes; that would make the numbers crowd together and look sloppy. The units should be marked at intervals that correspond more or less to the intervals between the experimental points. The small marks, called **index marks**, can be drawn in if the experimental points are very widely spaced. Most elegantly, a **frame** is put around the whole graph, and index marks are placed all around. This makes it easy to lay a ruler across the graph when interpolating between the experimental points. The diagram in Figure A.7 summarizes some features of a good graph.

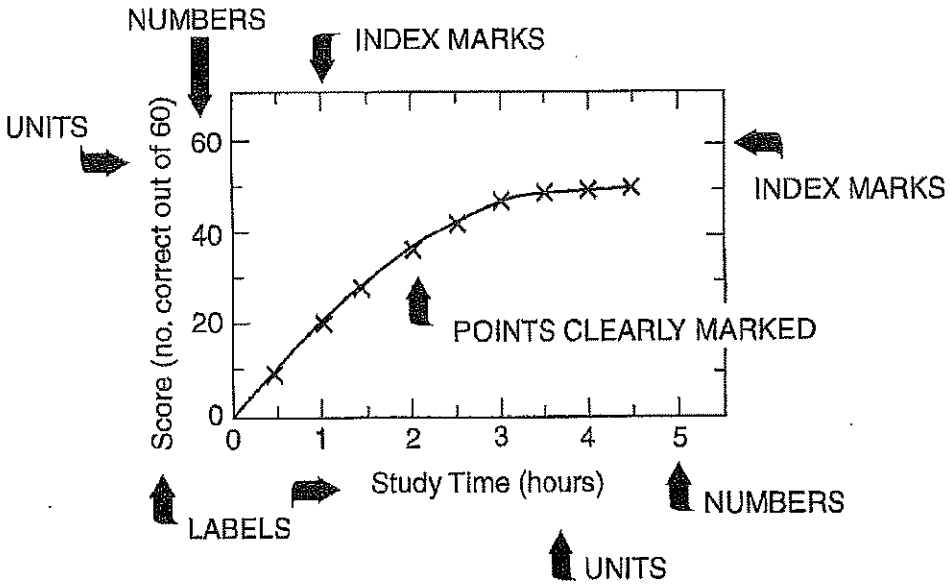
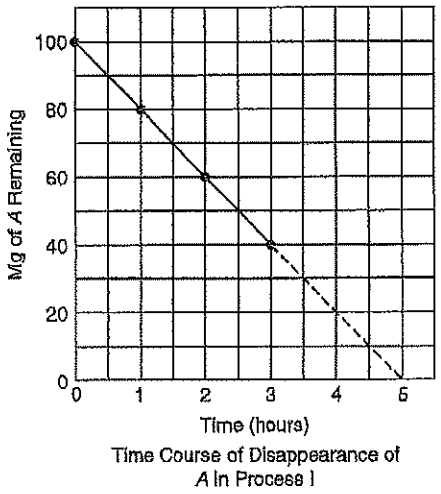


Figure A.7: Relation Between Study Time and Score on a Biology Exam in 2011

STEEPNESS OR SLOPE OF A LINE GRAPH

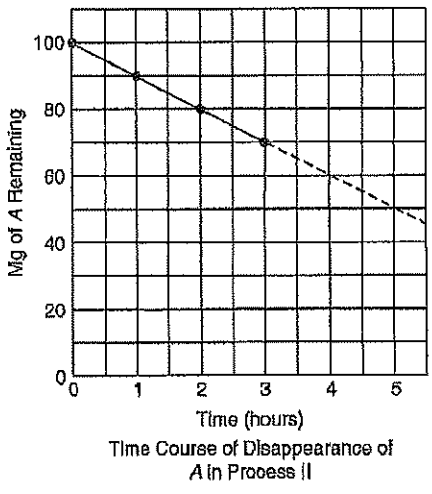
Look at the graph in Figure A.8 for the disappearance of *A* in a chemical reaction. Such a graph, in which the amount of some quantity is shown on the vertical scale, or **ordinate**, with time shown on the horizontal scale, or **abscissa**, is frequently called a "progress graph" or "progressive curve," because it shows how some process progresses in time. This graph may also be called a "time course" for the process because it shows the extent to which the process has occurred at different times.



Time Course of Disappearance of *A* in Process I

Figure A.8

Let us call the process represented by the graph "Process I" and consider another reaction, "Process II," in which *A* is also consumed. Suppose that we start Process II also with 100 mg of *A*, and that after 1, 2, and 3 hours there are 90, 80, and 70 mg, respectively, left. The progress curve for Process II is displayed in Figure A.9.

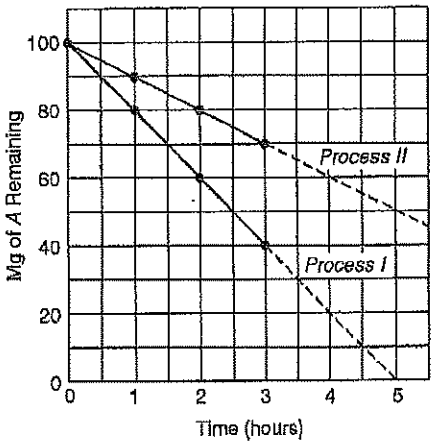


Time Course of Disappearance of *A* in Process II

Figure A.9

Now, suppose we want to compare the graphs for the two processes. Because they have exactly the same scales, we can put both lines on the same graph, as shown in Figure A.10. Notice, however, that now in addition to the labels on the scales, we need labels on the two lines to distinguish between the two processes.

Look at the 1-hour mark on the time scale of the graph. Opposite this put an X on the line for Process I and a Y on the line for Process II. Then, opposite X on the ordinate you should be able to see that 80 mg of *A* are left in Process I; opposite Y you can see that 90 mg of *A* are left in Process II. Apparently, Process I has used up 20 mg of *A* and Process II has used up only 10 mg in the same amount of time. Obviously, Process I is faster, and the line graph for Process I is steeper than the graph for Process II.



Time Course of Disappearance of *A* in Process I and II

Figure A.10

The rate for Process I is 20 mg A used/hr, while the rate for Process II is 10 mg *A* used/hr.

We have seen that a steeper line graph means a faster reaction when the progress curves for two reactions are plotted on the same scale. (Obviously, if the progress curves are plotted on different scales, we cannot compare the steepness of the line directly, but have to calculate what the slope would be if the two curves were plotted on the same scale.)

Suppose, now, that we make a new kind of graph, one that will show the steepness, or slope, of the progress curve. Because the **slope** of the progress curve is a measure of the speed of velocity, or **rate** of the reaction or process, such a graph is frequently called a "rate graph" or "rate curve." The diagram in Figure A.11 shows how a rate curve can be made for Process I.

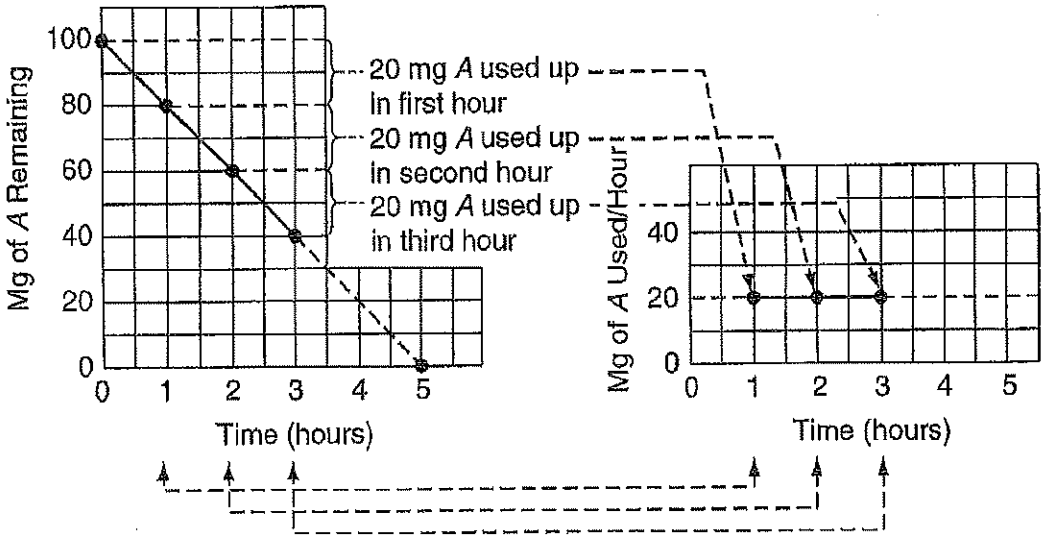


Figure A.11

Notice that the time scale of this rate graph is exactly like the time scale of the progress curve from which it was derived, but that the ordinate is different. The ordinate of the progress curve shows milligrams of *A* remaining; the ordinate of the rate curve shows milligrams of *A* used per hour. Obviously, a rate graph must always show rate on one of its scales, and it is ordinarily the vertical one that is used. This is because the rate of a reaction or process is what mathematicians call a **dependent variable**. Time is the **independent variable** in this experiment; it is independent of changes in the dependent variable (the rate of reaction), and it is the variable that is shown on the horizontal axis. Regardless of whether the process is the increase in height or weight of a plant, or the using up or producing of something in a reaction, the rate graph for the process must always show *amount of something per unit time* on one of its axes. One very common type of rate graph is the one shown in Figure A.11, with a rate on the ordinate and the time on the abscissa. Other kinds of rate graphs may have temperature or molarity on the abscissa. The rate of growth of a plant, for example, depends on how many factors that we might wish to vary, and so we can have as many different kinds of rate graphs for that process as there are independent variables.

Let us emphasize: a progress curve always shows amount of reaction on the vertical scale and time on the horizontal scale. The corresponding rate curve *may* show time or some other variable on the horizontal scale, but it *always* shows rate, or amount of reaction per unit time, on the vertical scale. This point is very important. When we look at a rate curve that has time on the horizontal scale, we must visualize the progress curve from which the rate curve was derived. When we look at a rate curve that has any other variable except time on the horizontal scale, we shall see that each point on the rate curve represents a separate progress curve.

In the same way as for Process I, a rate curve can be made for Process II. Plotted on the same graph, the two should look something like the diagram in Figure A.12.

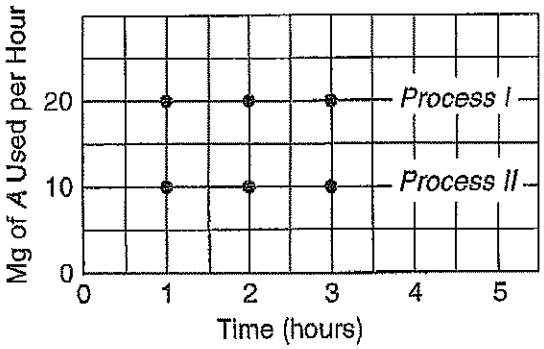


Figure A.12

There are two things to notice in this example. First, the curve for Process I lies higher than that for Process II. This is in accord with the facts as we have seen them, namely, that Process I is faster and so has a greater slope or higher value for the steepness. Second, notice that both curves are perfectly flat. Naturally, because the progress curves for the two processes were both perfectly straight lines, having everywhere the *same* slope, the rate of steepness graph must show exactly the same thing, that is, that the rate or steepness is everywhere the same.

On the other hand, consider the graph in Figure A.13, which represents the disappearance of *A* in yet another reaction, Process III.

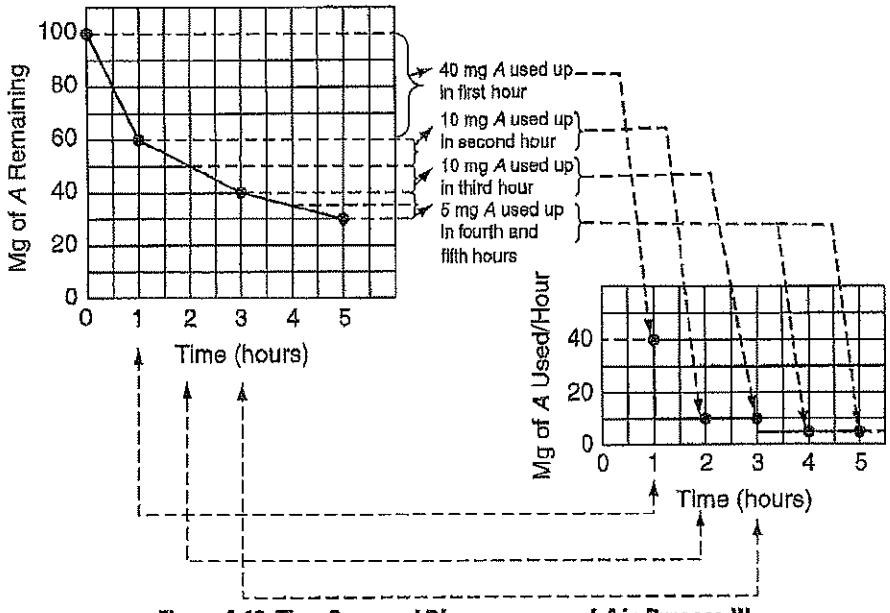


Figure A.13: Time Course of Disappearance of *A* in Process III

You can see that Process III differs from Processes I and II in that the progress curve for III is not a perfectly straight line. It is steepest at the beginning, becomes less steep after 1 hour, and again after 3 hours. Obviously, because the rate of the process is changing with time, the corresponding rate curve will not be perfectly flat. The rate has to start out high, then drop at 1 hour and at 3 hours, and you can see in the graph on the right

that this is exactly what it does. In fact, the rate curve looks like steps because whenever the slope of the progress curve decreases, the rate curve must show a drop to a lower value. Conversely, if the progress curve for a process should get steeper, as sometimes happens (the reaction goes faster after it gets "warmed up"), the rate curve must show a corresponding increase to a higher value.

Until now we have been able to read the steepness, or slope, of the progress curve directly from the scales of the graph because the progress curves we have been studying were either perfectly straight lines or else made up of straight-line segments. In most real situations, however, we cannot do this because the slope of the progress curve does not change sharply at a given time, but, gradually, over a period of time. You probably remember how to measure the slope of a curved line, but let us review the process anyway. (See Figure A.14.)

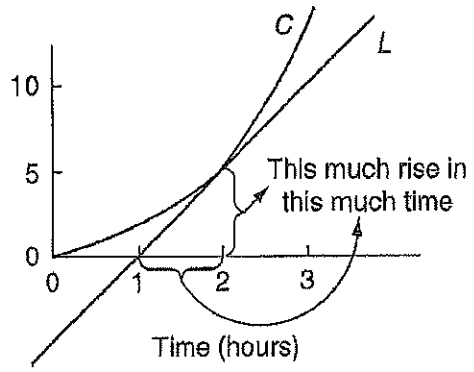
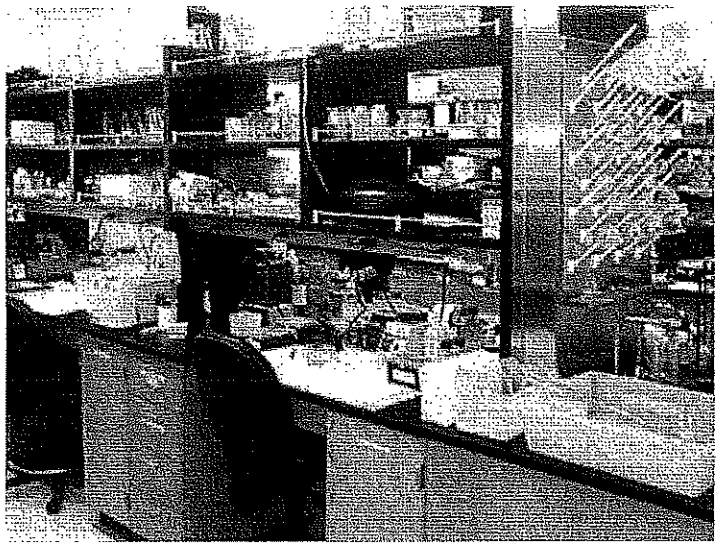


Figure A.14

Suppose we want to measure the slope, or steepness, of the curved line C at time 2 hours. We can see that the curve rises 5 units total in the 2 hours, so that the average slope is 2.5 units per hour. However, it is easy to see from the graph that this average is very misleading; the progress curve is almost flat at the beginning (i.e., has 0 slope) and then accelerates rapidly, so that the line curves upward. If we want to find the true slope at 2 hours, we must draw line *L* in such a way that *L* has the same slope as *C* at the 2-hour point. Then we can see that L rises about 5 units between 1 and 2 hours, just twice the average slope for the first 2 hours.

We have seen that a perfectly flat curve, like that for Process I or II, means that the corresponding progress curve is a perfectly straight line having the same slope at all points. Conversely, a progress curve that changes in slope, like that of Process III, will give a rate curve that looks like steps. You should be able to figure out that the "steps" on the rate curve will be sharp and square if the progress curve has an abrupt change in slope, and more rounded off if the progress curve changes slope gradually. In any case, in regions where the rate curve is perfectly flat it is clear that the progress curve must have constant steepness, or slope. However, if the progress curve itself gets perfectly flat, then that portion of the progress curve has 0 slope; in other words, the reaction has stopped. This kind of situation is pictured in Figure A.15 where the rate and progress curves for another reaction, call it Process IV, are shown.

Intro To Labs for Advanced Placement Biology



Contents

Click on the hyperlink title you wish to view

Levels of Scientific Inquiry

- **Confirmation**: Students confirm a principle through an activity in which the results are known in advance.
- **Structured**: Students investigate a teacher-presented question through a prescribed procedure.
- **Guided**: Students investigate a teacher-presented question using student-designed/selected procedures.
- **Open**: Students investigate topic-related questions that are formulated through student-designed/selected procedures.

THE SCIENTIFIC METHOD

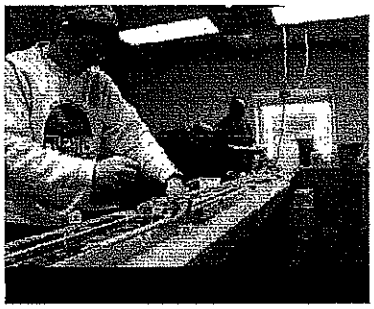
- Scientific knowledge grows through a process called the **scientific method.**
- This process involves
  - observation and measurement
  - hypothesizing and predicting
  - and planning and executing investigations designed to test formulated **hypotheses.**

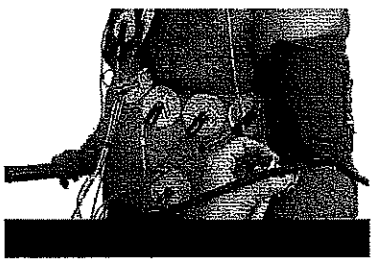
THE SCIENTIFIC METHOD

- **Observations, Hypotheses, and Predictions**

Making Observations

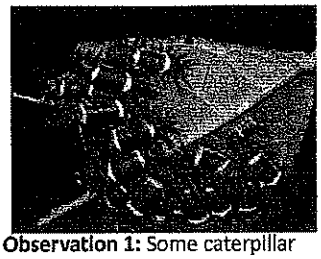
- Many types of observation can be made on biological systems. They may involve:
  - observation of certain behaviors in wild populations
  - physiological measurements made during previous experiments
  - 'accidental' results obtained when seeking answers to completely unrelated questions
- The observations may lead to the formation of questions about the system being studied.



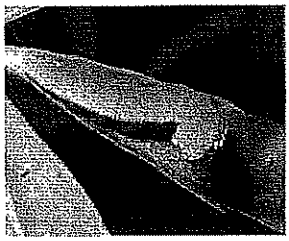


THE SCIENTIFIC METHOD

- **Observations-**
- Observation is the basis for formulating hypotheses and making predictions. An observation may generate a number of plausible hypotheses, and each hypothesis will lead to one or more predictions, which can be tested by further investigation.



Observation 1: Some caterpillar species are brightly colored and appear to be conspicuous to predators such as insectivorous birds. Predators appear to avoid these species. These caterpillars are often found in groups, rather than as solitary animals.



Observation 2: Some caterpillar species are cryptic in their appearance or behavior. Their camouflage is so convincing that, when alerted to danger, they are difficult to see against their background. Such caterpillars are usually found alone.

THE SCIENTIFIC METHOD

- A hypothesis offers a tentative explanation to questions generated by observations and leads to one or more **predictions** about the way a biological system will behave.
- ***A hypothesis is like "stereotyping":***
  - For example, *We know that tomatoes are fruits, that many fruits produce ethylene, and that ethylene promotes fruit ripening.*
  - *If tomatoes produce ethylene, then placing them in a container that traps ethylene will cause the tomatoes to ripen faster.*

THE SCIENTIFIC METHOD

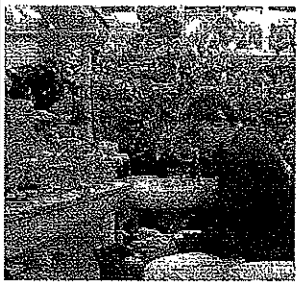
- **Hypothesis:**
  - A scientific hypothesis is a tentative explanation for an observation which is capable of being tested by experimentation.
  - Hypotheses lead to **predictions** about the system involved and they are accepted or rejected on the basis of the investigation's findings.
  - Acceptance of the hypothesis is not necessarily permanent: explanations may be rejected later in light of new findings.
- **Forming a Hypothesis**
  - **Features of a sound hypothesis:**
    1. It is based on observations and prior knowledge of the system.
    2. It offers an explanation for an observation.
    3. It refers to only one independent variable.
    4. It is written as a definite statement and not as a question.
    5. It is testable by experimentation.
    6. It leads to predictions about the system.

THE SCIENTIFIC METHOD

- **Testing a Hypothesis**
  - **Features of a sound method:**
    1. It tests the validity of the hypothesis.
    2. It is repeatable.
    3. It includes a control which does not receive treatment.
    4. All variables are controlled where possible.
    5. The method includes a dependent and independent variable.
    6. Only the independent variable is changed (manipulated) between treatment groups.

THE SCIENTIFIC METHOD

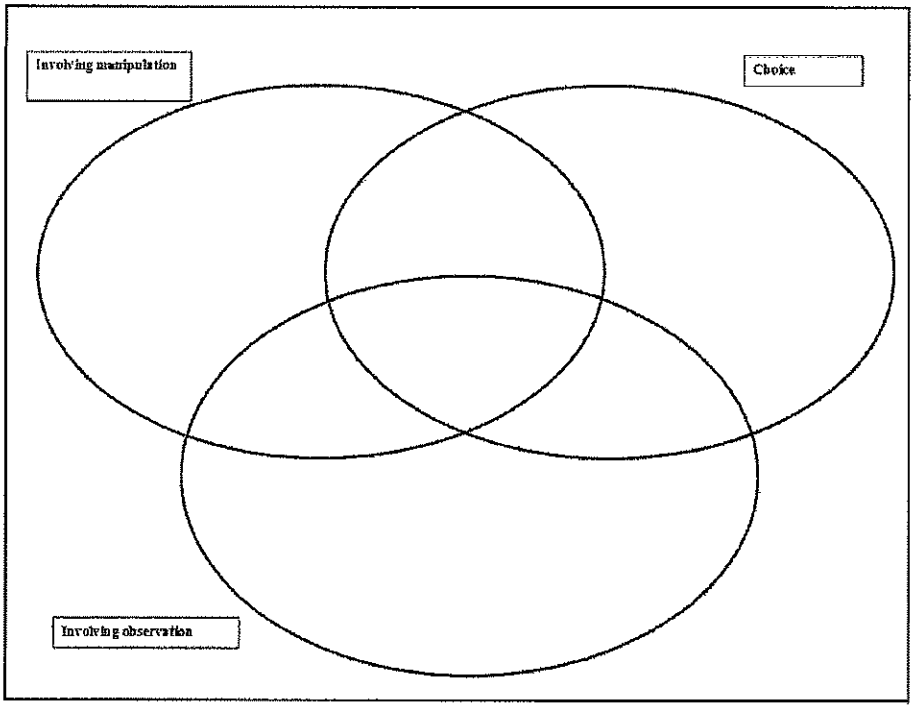
- **Types of Hypothesis**



Hypothesis involving manipulation
Used when the effect of manipulating a variable on a biological entity is being investigated.
Example: The composition of applied fertilizer influences the rate of growth of plant A.

Hypothesis of choice
Used when investigating species preference, e.g. for a particular habitat type or microclimate.
Example: Woodpeckers (species A) show a preference for tree type when nesting.

Hypothesis involving observation
Used when organisms are being studied in their natural environment and conditions cannot be changed. **Example:** Fernabundance is influenced by the degree to which the canopy is established.



Formative assessment

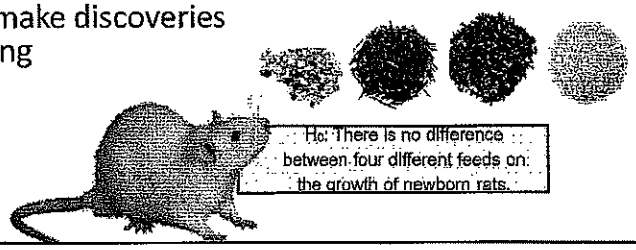
- **1.** Why might an accepted hypothesis be rejected at a later date? ---
  ---

- 2. Explain why a method must be repeatable:----------

- 3. In which situation(s) is it difficult, if not impossible, to control all the variables? ----------
  ---

The Null Hypothesis

- For every hypothesis, there is a corresponding **null hypothesis**; a hypothesis against the prediction, of **no difference** or **no effect**.
  - A hypothesis based on observations is used to generate the null hypothesis (H_0). Hypotheses are usually expressed in this form for the purposes of statistical testing.
  - H_0 may then be rejected in favor of accepting the alternative hypothesis (H_A) that is supported by the predictions.
  - Rejection of the hypothesis may lead to new, alternative explanations (hypotheses) for the observations.
- Scientific information is generated as scientists make discoveries through testing hypotheses.

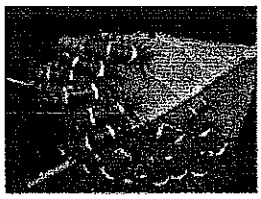


The Null Hypothesis

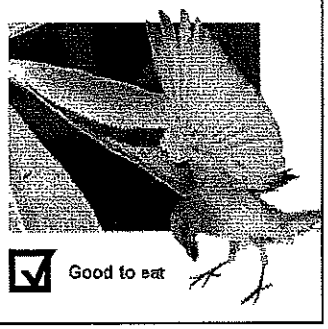
- Creating a null hypothesis enables a hypothesis to be tested in a meaningful way using statistical tests.
- If the results of an experiment are statistically significant, the null hypothesis can be rejected.
- If a hypothesis is accepted, anyone should be able to test the predictions with the same methods and get a similar result each time.
- Scientific hypotheses may be modified as more information becomes available

Generating Predictions

- There are several **hypotheses** and **predictions** that could be generated to account for the two previous observations:
  - **Hypothesis 1**: Bright colors signal to potential predators that the caterpillars are distasteful.
    - **Prediction 1**: Inexperienced birds will learn from a distasteful experience with an unpalatable caterpillar species and will avoid them thereafter.
  - **Hypothesis 2**: Inconspicuous caterpillars are palatable and their cryptic coloration reduces the chance that they will be discovered and eaten.
    - **Prediction 2**: Insectivorous birds will avoid preying on brightly colored caterpillars and they will prey readily on cryptically colored caterpillars if these are provided as food.



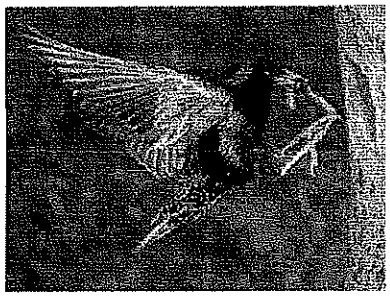
☒ Bad to eat



☑ Good to eat

Assumptions

- In any experimental work, you will make certain assumptions about the biological system you are working with.
- **Assumptions** are features of the system (and your experiment) that you assume to be true but do not (or cannot) test.
- Possible assumptions for the previous hypotheses (and their predictions) include:
  - Birds and other predators have color vision.
  - Birds and other predators can learn about the palatability of their prey by tasting them.



Formative assessment

- 1. Study the example above illustrating the features of cryptic and conspicuous caterpillars, then answer the following:
  - (a) Generate a hypothesis to explain the observation that some caterpillars are brightly colored and conspicuous while others are cryptic and blend into their surroundings:_____
  - (b) State the null form of this hypothesis: _____
  - (c) Describe one of the **assumptions** being made in your hypothesis: _____
  - (d) Based on your hypothesis, generate a **prediction** about the behavior of insectivorous birds towards caterpillars:__

Planning An Investigation

- Use a checklist or a template to construct a **plan** as outlined below:
  - **Preliminary**
    - Aim and hypothesis are based on observation.
    - Study is feasible and the chosen organism is suitable for study.
  - **Assumptions and variables**
    - Assumptions and variables have been identified and controls established.
    - Preliminary treatments or trials have been considered.
  - **Data collection**
    - Any necessary changes have been made to the initial plan.
    - A results table accommodates all raw data.
    - Data can be analyzed appropriately.

Observation is the starting point for any investigation

Variables

- A **variable** is any characteristic or property able to take any one of a range of values. Investigations often look at the effect of changing one variable on another (the biological response variable).
- It is important to identify all variables in an investigation: **independent**, **dependent**, and **controlled**. Note that there may be nuisance factors of which you are unaware.
- In all **fair tests**, only one variable (the independen variable) is changed by the investigator.

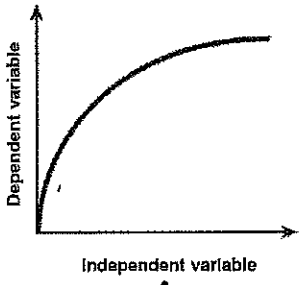
A terrarium experiment using a Pasco datalogger to record data

Identifying Variables

- All variables (**independent**, **dependent**, and **controlled**) must be identified in an investigation.

Dependent variable

☑ Measured during the investigation. Recorded on the Y axis of the graph.



Controlled variables

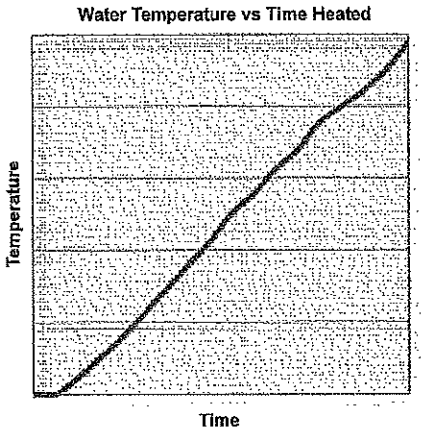
☑ Factors that are kept the same or controlled during the investigation. List these in the method as appropriate to your investigation.

Independent variable

☑ Set by the investigator. Recorded on the X axis of the graph.

Dependent and Independent Variables

- How the dependent variable changes depends on the changes in the independent variable, i.e. the dependent variable is influenced by the independent variable
- When heating water, the temperature of the water rises over time.
  - Therefore the temperature of the water is dependent upon the length of time it is left for.
  - Time is independent as it is not influenced by the temperature of the water.



Variables and Data

- **Data** are the collected values for monitored or measured **variables**.
  - Like their corresponding variables, data may be **qualitative**, **ranked**, or **quantitative** (or numerical).

Types of Variables

Qualitative
Non-numerical and descriptive, e.g. sex, color, presence or absence of a feature, viability (dead/alive).
e.g. Sex of children in a family (male, female)

Ranked
Provide data that can be ranked on a scale that represents an order, e.g. abundance (very abundant, common, rare), color (dark, medium, pale).
e.g. Birth order in a family (1, 2, 3)

Quantitative
Characteristics for which measurements or counts can be made, e.g. height, weight, number.

Discontinuous
e.g. Number of children in a family (3, 0, 4)

Continuous
e.g. Height of children in a family (1.5 m, 1.3 m, 0.8 m)

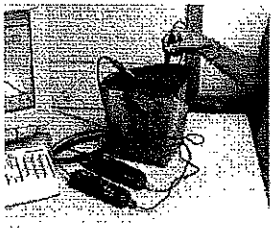
Examples of Investigations

- Once all of the variables have been identified in an investigation, you need to determine how these variables will be set and measured.
- You need to be clear about how much data, and what type of data, you will collect.
  - Some **examples of investigations** are shown below:

Aim		Variables	
Investigate the effect of varying ...	on the following...	Independent variable	Dependent variable
Temperature	Leaf width	Temperature	Leaf width
Light intensity	Activity of woodlice	Light intensity	Woodlice activity
Soil pH	Plant height at age 6 months	pH	Plant height

Stages In An Investigation

- Investigations involve **written stages** (**planning** and **reporting**), at the start and end. The middle stage is the **practical work** when the data are collected (in this case by data loggers as shown below).
  - Practical work may be based in the **laboratory** or in the **field** (the natural system).
    - Typically **lab work** involves investigating how a biological response is affected by manipulating a particular variable.
    - **Field work** often involves investigating features of a population or community. Investigations in the field are usually more complex than those in the lab because natural systems have many more variables that cannot easily be controlled.



Photos: Pasco

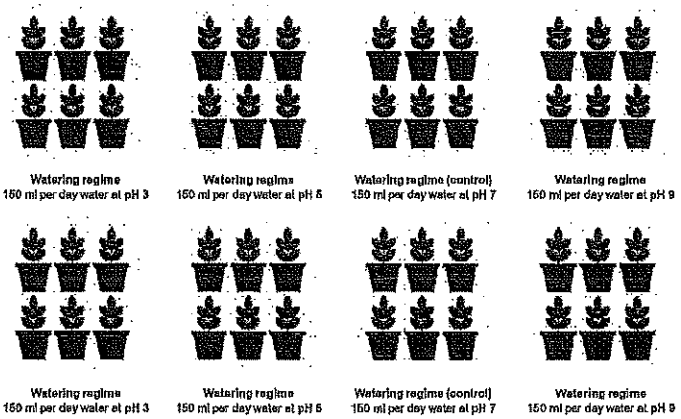
Sample Size

- When designing your field study, the size of your **sampling unit** and the **sample size** (*n*) should be major considerations.
  - A sampling unit might be (for example) an individual organism or a quadrat.
  - The sample size might be the number of individuals or the number of quadrats.
- For field studies, sample size is often determined by the resources and time available to collect and analyze your data.
- It is usually best to take as many samples as you can, as this helps to account for any natural variability present and will give you greater confidence in your data.

Sample (*n*=23)

Replication

- **Replication** in experiments refers to the number of times you repeat your entire experimental design (including controls).
  - Increasing the sample size (*n*) is not the same as true replication. In the replicated experiment below, *n*=6.

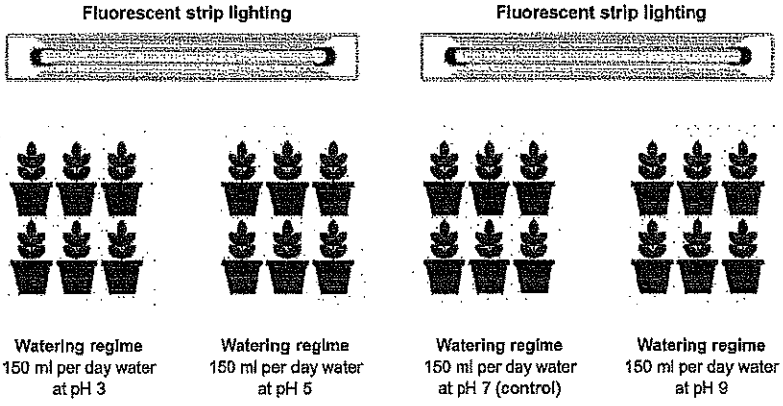


Making Investigations 1

- An **example** of a basic experimental design aimed at investigating effect of pH on the growth of a bog adapted plant species follows:
  - **Observation**: A student noticed an abundance of a common plant (species) in a boggy area of land. The student tested the soil pH and found it to be quite low (between 4 and 5). Garden soil was about pH 7.
  - **Hypothesis**: Species A is well adapted to grow at low pH and pH will influence the vigor with which this plant species grows.
  - **Prediction**: Species A will grow more vigorously (as measured by wet weight after 20 days) at pH 5 than at lower or a higher pH.

Making Investigations 2

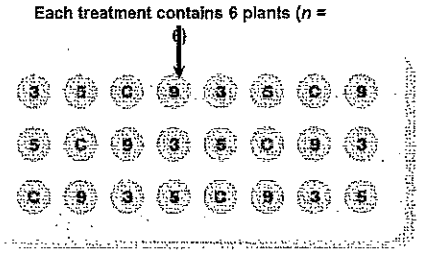
- **Experiment:** An experiment was designed to test the prediction that the plants would grow best at low pH. The design is depicted graphically below and on the next slide. It is not intended to be a full methodology.



Making Investigations 3

Plan view of the experimental layout

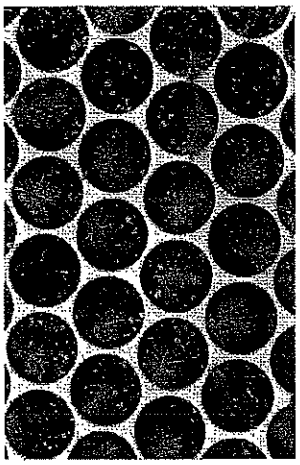
3 = pH 3
5 = pH 5
C = control (pH 7)
9 = pH 9



- **Note** that in experiments with a large number of treatments and replication, it is important to randomize the arrangement of the treatments to account for any effects of location in the set-up.
  - In this case, $n = 6$, there are four different treatments and the experiment has been replicated six times.

Making Investigations 4

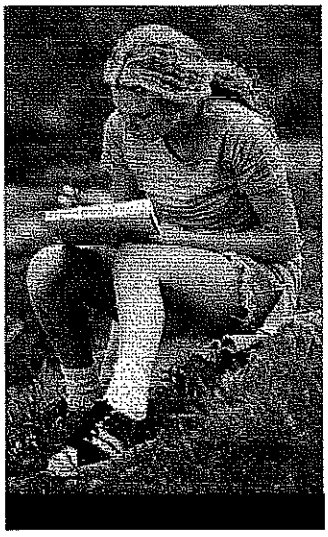
- **Control of variables:**
  - **Fixed variables** include lighting and watering regime, soil type and volume, age and history of plants, pot size and type.
  - The **independent variable** is the pH of the water provided to the plants.
  - The **dependent variable** is plant growth rate (g day^{-1}) calculated from wet weight of entire plants (washed and blotted) after 20 days.
  - Other variables include genetic variation between plants and temperature.
- **Assumptions** include: All plants are essentially no different to each other in their growth response at different pH levels; the soil mix, light quality and quantity, temperature, and water volume are all adequate for healthy continued growth.



Certain variables, such as pot size and plant age, can be fixed when plants are grown under controlled conditions

Collection and Analysis

- Data collected by measuring or counting in the field or laboratory are called **raw data.**
  - As part of planning an investigation, a suitable **results table** must be designed to record raw data.
- Once all the required data has been collected, they need to be analyzed and presented.
  - To do this, it may be necessary to **transform** or **process** the data first.



Transformations

- Data are often transformed as a first step in the analysis of results.
  - Transforming data can make them more useful by helping to highlight trends and make important features more obvious.
- **Transformations** include drawing a frequency table, or performing a calculation such as a total, rate, percentage, or relative value.
  - Calculation of a rate is a commonly performed data transformation, and is appropriate when studying the growth of an organism (or population).
  - Biological investigations often compare the rates of events in different situations, as shown in the example right.

Photosynthetic rate at different light intensities

Light intensity (%)	Average time for leaf disc to float (min)	Reciprocal of time (min^{-1})
100	15	0.067
50	20	0.050
25	60	0.017
11	85	0.012
6	190	0.005

Constructing Tables 1

- Data can be presented in a number of ways.
  - **Tables** provide an accurate record of numerical values and allow organization of data in a way that makes relationships and trends apparent. An example of a well constructed table is shown below:

Table 1: Length and growth of the third internode of bean plants receiving three different hormone treatments (data are given ± standard deviation).

Treatment	Sample size	Mean rate of internode growth ($mm\ day^{-1}$)	Mean internode length (mm)	Mean mass of tissue added ($g\ day^{-1}$)
Control	60	0.60 ± 0.04	32.3 ± 3.4	0.36 ± 0.025
Hormone 1	48	1.52 ± 0.08	41.6 ± 3.1	0.51 ± 0.030
Hormone 2	68	0.82 ± 0.05	38.4 ± 2.9	0.56 ± 0.028
Hormone 3	85	2.06 ± 0.19	50.2 ± 1.8	0.68 ± 0.020

Constructing Tables 2

- The **rules** for **constructing tables** are shown below:

Tables should have an accurate, descriptive title. Number tables consecutively through the report.

Independent variable in left column

Table 1: Length and growth of the third internode of bean plants receiving three different hormone treatments (data are given ± standard deviation).

Treatment	Sample size	Mean rate of internode growth (mm day⁻¹)	Mean internode length (mm)	Mean mass of tissue added (g day⁻¹)
Control	50	0.60 ± 0.04	32.3 ± 3.4	0.36 ± 0.025
Hormone 1	46	1.52 ± 0.08	41.6 ± 3.1	0.51 ± 0.030
Hormone 2	98	0.82 ± 0.05	38.4 ± 2.9	0.56 ± 0.028
Hormone 3	85	2.06 ± 0.19	50.2 ± 1.8	0.68 ± 0.020

Heading and subheadings identify each data and show units of measurement.

Control values should be placed at the beginning of the table.

Tables can be used to show a calculated measure of spread of the values about the mean (e.g. standard deviation).

Each row should show a different experimental treatment, organism, sampling site etc.

Columns that need to be compared should be placed alongside each other.

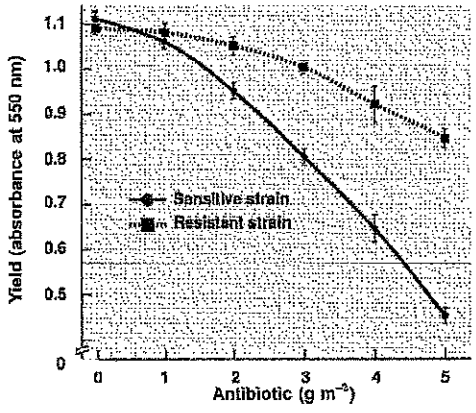
Show values only to the level of significance allowable by your measuring technique.

Organize the columns so that each category of like numbers or attributes is listed vertically.

Constructing Graphs 1

- Graphs are useful for providing a visual image of trends in the data in a minimum of space.

Fig. 1: Yield of two bacterial strains at different antibiotic levels. Vertical bars show standard errors (n = 6).



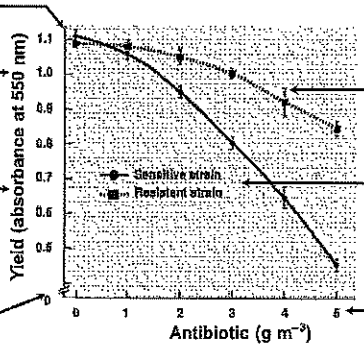
Constructing Graphs 2

- The **rules** for **constructing graphs** are shown below:

Graphs (called figures) should have a concise, explanatory title. They should be numbered consecutively in your report.

Plot points accurately. Different responses can be distinguished using different symbols, lines or bar colors.

Fig. 1: Yield of two bacterial strains at different antibiotic levels. Vertical bars show standard errors (n = 6)



Label both axes (provide SI units of measurement if necessary)

The dependent variable e.g. biological response, is plotted on the vertical (y) axis

A break in an axis allows economical use of space if there are no data in the "broken" area. A floating axis (where zero points do not meet) allows data points to be plotted away from the vertical axis.

The independent variable, e.g. treatment, is on the horizontal (x) axis

The spread of the data around the plotted mean value can be shown on the graph. Such measures include standard deviation and range. The values are plotted as error bars and give an indication of the reliability of the mean value.

A key identifies symbols. This information sometimes appears in the title.

Each axis should have an appropriate scale. Decide on the scale by finding the maximum and minimum values for each variable.

Descriptive Statistics 1

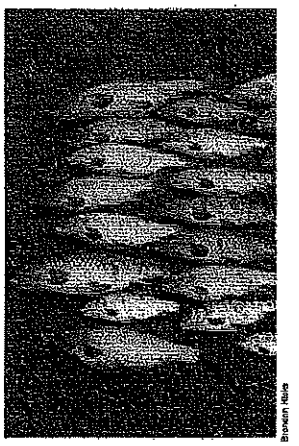
- **Descriptive statistics**, such as **mean**, **median**, and **mode**, can be used to summarize data and provide the basis for statistical analysis.
  - Each of these statistics is appropriate to certain types of data or distributions, e.g. a mean is not appropriate for data with a skewed distribution.
- Standard deviation and standard error are statistics used to quantify the amount of spread in the data and evaluate the reliability of estimates of the true (population) mean (μ).

Mean (average) height of this group of people is 1.7 m. But what is the variation in this statistic in the population?

Descriptive Statistics 2

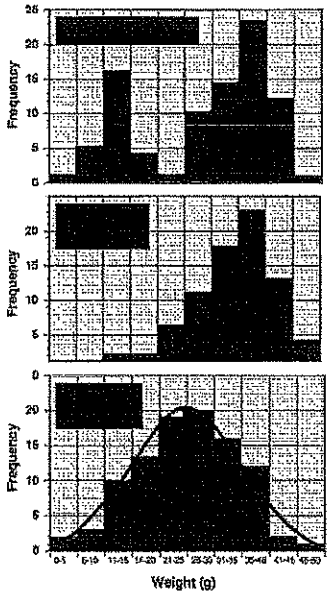
- In a set of data values, it is useful to know the value around which most of the data are grouped; the center value.
- Basic descriptive statistics can summarize trends in your data.

Statistic	Definition and use	Method of calculation
Mean	Average of all data entries. Measure of central tendency for normal distributions	Add all data entries. Divide by the number of entries.
Median	Middle value when data are in rank order. Measure of central tendency for skewed distributions.	Arrange data in increasing rank order. Identify the middle value.
Mode	Most common data value. Good for bimodal distributions and qualitative data.	Identify the category with the highest number of data entries.
Range	The difference between the smallest and largest data values. Gives a crude indication of data spread.	Identify largest and smallest values and calculate the difference between them.



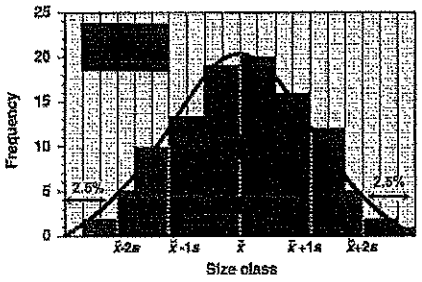
Frequency Distributions

- Variability in continuous data is often displayed as a **frequency distribution**.
- A frequency plot will indicate whether the data have a **normal** distribution, or whether the data is **skewed** or **bimodal**.
- The shape of the distribution will determine which statistic (mean, median, or mode) best describes the central tendency of the sample data.



Measuring Spread

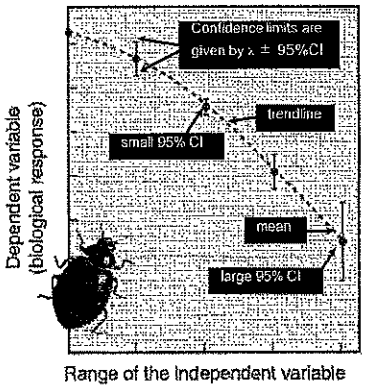
- **Standard deviation** (s) is a frequently used measure of the variability (**spread** or dispersion) in a set of data. Two different sets of data can have the same mean and range, yet the distribution of data within in the range can be quite different.
  - In a normally distributed set of data:
    - 68% of all data values will lie within one standard deviation of the mean;
    - 95% of all data values will lie within two standard deviations of the mean.



- The variance (s^2) is another such measure of dispersion but the standard deviation is usually the preferred of these two measures.

The Reliability of the Mean

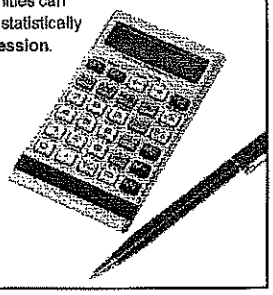
- The **reliability** of the **sample mean** ($\bar{x}$) as an estimate of the true population mean can be indicated by the calculation of the standard error of the mean (**standard error** or SE). The standard error then allows the calculation of the **95% confidence interval** (95% CI) which can be plotted as error bars.
- The **95% confidence limits** are given by the value of the mean ± 95%CI.
  - A 95% confidence limit (i.e. P = 0.05) tells you that, on average, 95 times out of 100, the true population mean will fall within these limits.
  - For example, if we calculated the mean number of spots on 10 ladybirds, the 95%CI will tell us how reliable that statistic is as an indicator of the mean number of carapace spots in the whole population.



Statistical Tests

- Different **statistical tests** are appropriate for different types of data. The type of data collected will determine how/if it can be tested.
- The **null hypothesis** of no difference or no effect can be tested statistically and may then be rejected in favor of accepting the **alternative hypothesis** that is supported by the predictions.
- Statistical tests may test for:
  - a **difference** between treatments or groups.
  - a **trend** (or relationship) in the data, for example, correlation and regression.

The weight change of shore crabs held at different salinities can be analyzed statistically using a regression.



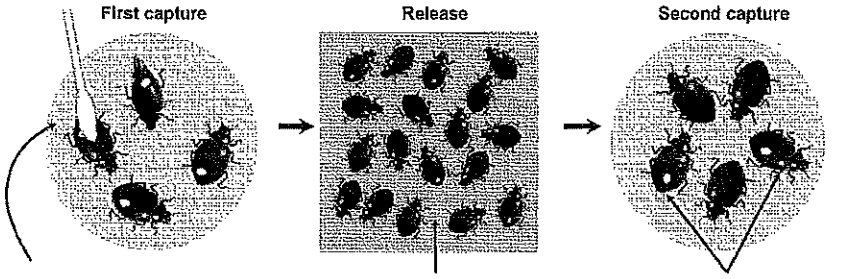
Sampling Populations

- Generally populations are too large to be examined **directly** (by direct count or measurement of all the individuals in the population), but they must be sampled in a way that still provides representative information about them.
- Most studies in population ecology involve collecting living organisms. **Sampling techniques** must be appropriate to the community being studied and the information required by the investigator.
  - Sampling techniques include:
    - **point sampling**
    - **transect (line and belt)**
    - **quadrat sampling**
    - **mark and recapture**

Inserting a visual implant tag in a mark and recapture study of carp

Mark and Recapture

- **Mark and recapture** is used to determine the total population density for highly mobile species in a certain area.
  - For a precise population estimate, mark-recapture methods require that about 20% of the population is marked, which can be difficult. Also, marking is difficult for small animals.



In the first capture, a random sample of animals from the population is selected. Each selected animal is marked in a distinctive way.

The marked animals from the first capture are released back into the natural population and left to mix with the unmarked individuals.

The population is sampled again; only a proportion of the second capture sample will have animals that were marked in the previous capture.

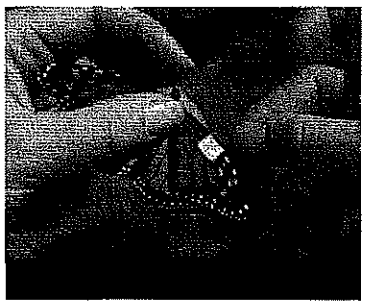
The Lincoln Index

- This **equation** is used to estimate the size of the overall population.

The Lincoln Index

$$\text{Total population} = \frac{\text{No. of animals in 1st sample} \times \text{Total no. of animals in 2nd sample}}{\text{Number of marked animals in the second sample (recaptured)}}$$

1. The population is sampled by capturing as many of the individuals as possible and practical.
2. Each animal in the sample is marked to distinguish it from unmarked animals.
3. Animals are returned to their habitat and left to mix with the rest of the population.
4. The population is sampled again (this need not be the same sample size as the first, but it must be large enough to be valid).
5. The numbers of marked to unmarked animals in this second sample is determined. The Lincoln Index is used to estimate overall population size.



Accuracy and Precision

- The terms accuracy and precision are often confused, or used interchangeably, but their meanings are different.
- In any study, **accuracy** refers to how close a measured or derived
- value is to its true value.
- Simply put, it is the correctness of the measurement. It can sometimes be a feature of the sampling equipment or its calibration.
- **Precision** refers to the closeness of repeated measurements to each other, i.e. the ability to be exact. A balance with a fault in it could give very precise (i.e. repeatable) but inaccurate (untrue) results.

Conclusions:

1. Summarize Results
2. See if hypothesis was support/rejected and evidence that lead you to this conclusion
3. Biological concept explains results?
4. Possible errors in experiment