

# Biology 3101C

## Genetics and Evolution

# Study Guide

**Prerequisite:** Biology 2101A, Biology 2101C  
Biology 3101A, Biology 3101B

**Credit Value:** 1

**Text:** *Biology*. Bullard, Chetty, et al; McGraw-Hill Ryerson, 2003

**Biology Concentration**

Biology 1101  
Biology 2101A  
Biology 2101B  
Biology 2101C  
Biology 3101A  
Biology 3101B  
**Biology 3101C**



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## To the Student

### I. Introduction to Biology 3101C

Biology 3101C is the third of the three courses (the others are Biology 3101A and Biology 3101B) that are equivalent to Biology 3201 in the current high school system.

Biology 2101A, *The Cell*, Biology 2101C, *Maintaining Dynamic Equilibrium I*, Biology 3101A, *Maintaining Dynamic Equilibrium II*, and Biology 3101B, *Reproduction and Development*, are **pre-requisites** for this course. However, before deciding to leave out any courses in the Biology concentration, you should ensure that you are aware of what courses you will need to complete in order to meet the entrance requirements for the receiving post-secondary institution that you plan to attend.

This is a **1 credit** course that is divided into 2 parts.

Part 1, ***Genetic Continuity***, will provide you with the basic information required for the comprehension of genetics. Much of the structure and function of every living organism is determined by deoxyribonucleic acid (DNA). It is important for a scientifically literate person to understand principles and fundamentals about DNA: what it is, how it works, how and for what purposes humans are manipulating it, and why this major area of scientific and technological endeavour has dramatic implications for humans and planet earth.

Part 2, ***Evolution, Change, and Diversity***, focuses on the history, importance and mechanisms of the process of evolution and how a change in the DNA blueprint creates new traits that propel evolution. It builds upon what you have learned about mutations and genetic variability and shows how these can lead to changes in species based upon natural selection.

You will have labs for this unit. Let your instructor know in advance that you are getting close to needing to do a lab. The lab will require a written lab report, which will be evaluated as part of your course mark. In addition, there are assignments that you will be required to complete and submit to your instructor for marking. The marks that you get on the labs and assignments will contribute to your final mark in the course.

## To the Student



### II. Use of Science Study Guides

Before beginning this course, ensure you have the text and any other resources needed (*see the information in the Introduction to this course for specifics*).

As you work through the Study Guide, you will see that it is divided according to the Units listed in the Table of Contents. When you open a unit it will have the following components:

#### Reading for this Unit:

Here you will find the chapters, sections and pages of the text you will use to cover the material for this unit. Skim the sections of the textbook, look at the titles of the sections, scan the figures and read any material in the margins. Once you have this overview of the unit, you are ready to begin. Do not be intimidated by the content. You will work through the text, section by section, gaining knowledge and understanding of the material as you go.

<p><b>References and Notes</b></p> <p>This left hand column guides you through the material to read from the text. Read any highlighted notes that follow the reading instructions. The symbols   direct you to the questions that you should complete when finished a reading assignment..</p>	<p><b>Work to Submit</b></p> <p>You come across three (3) headings in this right hand column.</p> <p><b>Writing:</b> This section comprises your notes for the unit. Here you will find either written questions or references to specific questions or problems from your text. You may want to write out each question followed by the answer. This material should be checked by your instructor before moving on to the next unit. Mathematical problems should have their solutions checked <u>as you go</u>.</p> <p><b>Laboratory:</b> This section indicates if there is a Core Lab that should be completed for the unit. Let the instructor know in advance that you will be ready for the lab. A lab report should be submitted for each Core Lab. Your instructor will provide guidelines as to how s/he wants the report written.</p> <p><b>Assignment:</b> This section indicates if there is an assignment that should be completed for the Unit. The information in the “References and Notes” column will indicate how you obtain the assignment. These assignments frequently relate the science content to technology, society and the environment.</p>
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## To the Student

### III. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam ( <i>entire course</i> )	<u>50%</u>
	100%

**The overall pass mark for the course is 50%.**





# **Part I - Genetic Continuity**

## Unit 1 - Genetics: Mendelian

To fulfill the objectives of this unit, students should complete the following:

### Reading for this unit:

*Biology*

Chapter 16: Introduction: page 524

Section 16.1: pages 526-534

Section 16.2: pages 536 - 544

### References and Notes

Referring to Section 16.1, write answers for questions 1.1 - 1.2



#### Note:

In addition to the words you are explaining by answering the questions, you should know how to use the following terms correctly as you complete the writing for this section:

- genetics
- true breeding
- Mendelian ratio
- gamete
- unit characters

#### Note:

The glossary will be helpful with definitions.

You should also ensure that you are familiar with the work of Gregor Mendel.

### Work to Submit

#### Writing:



1.1 Define the terms heredity and genetics.



1.2 Explain the meaning of the following terms:

- (i) trait
- (ii) variations
- (iii) P generation (parent generation)
- (iv) F<sub>1</sub> and F<sub>2</sub> generation (first and second filial generation)
- (v) hybrid
- (vi) purebred
- (vii) complete dominance
- (viii) monohybrid cross
- (ix) dominant
- (x) recessive
- (xi) gene
- (xii) allele
- (xiii) homozygous
- (xiv) heterozygous
- (xv) Punnett square
- (xvi) genotype
- (xvii) phenotype

## Unit 1 - Genetics: Mendelian



### References and Notes

Review carefully the Punnett Square in Fig. 16.9 and the Sample Problem on page 533, then complete 1.3  

Referring to pages 529 - 530, write answers for questions 1.4 - 1.5  

#### Viewing:

If you have internet access, go to <http://www.mcgrawhill.ca/school/booksites/biology/student+resources/to/c/index.php> and view the movie on Punnett squares.

Referring to pages 536 - 541, write answers for questions 1.6 - 1.10  

#### Note:

Review carefully the Punnett Square in Fig. 16.13 and the Sample Problem on page 540, before completing question 1.7.

See your instructor for extra practice using Punnett squares to determine the outcome of monohybrid and dihybrid crosses.

### Work to Submit

#### Writing:

1.3 Complete “Practice Problems” 1,2,3 on page 533. (Check your answers in the back of the book and make sure that you fully understand them before moving on.)

1.4 (a) Explain Mendel’s **principle of dominance**.  
(b) Sketch a Punnett square of the cross shown in Fig. 16.6 to illustrate the principle of dominance.

1.5 (a) Explain Mendel’s **law of segregation**.  
(b) Sketch a Punnett square of the cross shown in Fig. 16.7 to illustrate the law of segregation.

1.6 What is a dihybrid cross?



1.7 Complete “Practice Problem” 1 on page 540. (Check your answers in the back of the book.)

## Unit 1 - Genetics: Mendelian

### References and Notes

**Note:** The letters  $R$  and  $R'$ , rather than  $R$  and  $r$ , are used to show **incomplete dominance**.

**Note:** Two different uppercase letters are used to represent the alleles in codominance; e.g. the chicken shown in Fig. 16.16 has the genotype  $BW$ , where  $B$  represents the black allele and  $W$  represents the white allele.

Review carefully Table 16.1 and the Sample Problem on page 542, then complete question 1.11  

See your instructor for extra practice using Punnett squares to determine the outcome of crosses for incomplete dominance, co-dominance and multiple alleles.

See your instructor to discuss which questions you should do from the "Section Review" and/or "Chapter Review" for this unit.

### Work to Submit

#### Writing:

1.8 Explain the **law of independent assortment**.

1.9 (a) Explain what is meant by incomplete dominance.

(b) Sketch a Punnett square of the cross shown in Fig. 16.15 to illustrate the law of independent assortment.

(c) Complete problem #6 in the Section Review on page 544.

1.10 (a) Explain what is meant by co-dominance.

(b) Given that the alleles for feather colour in chickens are co-dominant, sketch a Punnett square to show a cross between a black rooster and a white hen.

1.11 (a) Explain what is meant by multiple alleles.

(b) Complete Practice Problem #1, page 542. (Check your answers in the back of the book.)

## Unit 2 - Genetics: Modern Ideas

To fulfill the objectives of this unit, students should complete the following:

**Reading for this unit:** *Biology*  
Chapter 16: Section 16.3: pages 545 - 553

### References and Notes

*Referring to Section 16.3, write answers for the questions 2.1 - 2.2*



*Review the concept of crossing-over by re-reading page 471 and studying Figure 14.15, page 473. Write an answer for question 2.3*



*Review carefully Figures 16.22 and 16.23 then complete questions 2.4 - 2.5*



*Referring to page 549, write an answer for the question 2.6*



*See your instructor for extra practice using Punnett squares to determine the outcome of crosses involving sex-linked traits.*

### Work to Submit

#### Writing:

- 2.1 State the chromosome theory of inheritance.
- 2.2 What is the gene-chromosome theory of inheritance?
- 2.3 (a) Explain what is meant by crossing over.  
(b) How does location of genes on a chromosome affect crossing-over?
- 2.4 (a) Define sex-linked inheritance.  
  
(b) On which sex chromosome are most genes located? Why?
- 2.5 Complete Section Review, #8.
- 2.6 Explain what is meant by polygenic inheritance and give 2 examples of polygenic traits.

## Unit 3 - Genetics: Molecular

To fulfill the objectives of this unit, students should complete the following:

### Reading for this unit: *Biology*

Chapter 17: Introduction: page 566  
Section 17.1: pages 568 - 572  
Section 17.2: pages 573 - 581  
Section 17.3: pages 582 - 587  
Section 17.4: pages 589 - 600

### References and Notes

*Referring to Section 17.1, write answers for questions 3.1 - 3.2*



*In addition to the words you are explaining by answering the questions, you should know how to use the following terms correctly as you complete the writing for this section:*

- *DNA (deoxyribonucleic acid)*
- *RNA (ribonucleic acid)*
- *nucleic acid*
- *nitrogenous base*

*Referring to Section 17.2, write answers for questions 3.3 - 3.5*



### Work to Submit

#### Writing:

3.1 (a) What is a nucleotide?

(b) What is a nucleotide composed of?

3.2 (a) What 4 nitrogenous bases are found in DNA?

(b) What 4 nitrogenous bases are found in RNA?

3.3 Describe the Watson and Crick double helix model of DNA.

3.4 Explain what is meant by complementary base pairings. (Name the base pairs that are complementary.)

3.5 What are the 3 key differences in the molecular structure of DNA and RNA?

## Unit 3 - Genetics: Molecular

### References and Notes

Referring to Section 17.3, write answers for questions 3.6 - 3.7 ▶▶

#### Note:

See your instructor to find out if another Lab will be done instead of the one mentioned below.

Referring to Investigation 17.B; "DNA Structure and Replication", pages 586-587, do the following ▶▶

Referring to Section 17.4, write answers for questions 3.8 - 3.14 ▶▶

In addition to the words you are explaining by answering the questions, you should know how to use the following terms correctly as you complete the writing for this section:

- *genetic code*
- *polypeptide*
- *amino acid*
- *codon*
- *mRNA(messenger RNA)*
- *rRNA(ribosomal RNA)*
- *tRNA(transfer RNA)*
- *anticodon*
- *ribosome*

### Work to Submit

#### Writing:

3.6 Explain what is meant by the semi-conservative model of DNA replication.

3.7 Name the three main stages of DNA replication and briefly describe what happens in each.

#### Laboratory:

3.8 Complete the investigation and record your observations.

(\*You may omit Post-Lab Questions, Conclude and Apply, and Exploring Further sections.)

#### Writing:

3.9 (a) What is meant by gene expression?  
(b) What are the 2 stages of gene expression?

3.10 Explain what is meant by transcription and tell where it takes place.

3.11 Explain what is meant by translation.

3.12 What is the function of mRNA?

3.13 What is the function of tRNA?

3.14 What is the function of rRNA?

## Unit 3 - Genetics: Molecular

### References and Notes

#### Viewing:

If you have internet access, go to <http://www.mcgrawhill.ca/school/booksites/biology/student+resources/toc/index.php> and view the movies on DNA replication, transcription and translation.

Assignment 1, Part 1, is found in Appendix B of this Study Guide. Refer to pages 550 - 553 to do the assignment. ▶▶

#### Note:

**The material covered in the assignment will not be tested. You should submit the completed assignment to your instructor for marking.**

Referring to the Lab. "Karyotyping" found in Appendix C, complete the following ▶▶

See your instructor to discuss which questions you should do from the "Section Review" and/or "Chapter Review" and any additional work that may be required for this unit.

### Work to Submit

#### Writing:

- 3.15 (a) Define mutation.
- (b) Explain the difference between germ cell mutations and somatic cell mutations.

#### Assignment:

- 3.16 Complete Assignment 1, Part 1, "Genetic Disorders".

#### Laboratory:

- 3.17 Complete all tasks as outlined in the Procedure.
- 3.18 Complete all questions in the Analysis section.



## Unit 4 - Genetics: Implications

To fulfill the objectives of this unit, students should complete the following:

**Reading for this unit:** *Biology*  
Chapter 16: Section 16.4: pages 555 -562  
Chapter 18: Section 18.1: pages 606-607  
Section 18.2: pages 618-620

### References and Notes

*The material in this unit is covered by completing Assignment 1, Part 2, found in Appendix B of this Study Guide. Refer to the pages listed in the **Reading for this Unit** to do the assignment. ▶▶*

**Note:**

*Autosomes are chromosomes that are not directly involved in determining the sex of an individual.*

**Note:**

*The material covered in the assignment will not be tested. You should submit the completed assignment to your instructor for marking.*

### Work to Submit

**Assignment:**

4.1 Complete Assignment 1, Part 2, “Genetics: Implications”.



## **Part II - Evolution, Change, and Diversity**

## Unit 5 - Evolutionary Change: Historical Perspectives

To fulfill the objectives of this unit, students should complete the following:

**Reading for this unit:** *Biology*  
Chapter 19: Introduction: page 642  
Chapter 19: Section 19.1: pages 644-649

### References and Notes

Referring to Section 19.1, write answers for questions 5.1 - 5.4 ▶▶

*In addition to the terms for which you are writing definitions, you should know how to use the following terms correctly as you complete the writing for this section:*

- *gene pool*
- *selective pressure*
- *fitness*

*See your instructor to discuss which questions you should do from the “Section Review” and/or “Chapter Review” and any other work that may be required for this unit.*

### Work to Submit:

#### Writing:

- 5.1 Define the terms:
- (i) evolution
  - (ii) adaptation
  - (iii) variation
- 5.2 (a) Explain what is meant by natural selection.  
(b) What condition is necessary for natural selection to occur?
- 5.3 Define and give an example of artificial selection.
- 5.4 Summarize the Peppered Moth story as an example of evolution and adaptation.

## Unit 6 - Evolutionary Change: Mechanisms of Evolution

To fulfill the objectives of this unit, students should complete the following:

### Reading for this unit:

*Biology*

Chapter 19: Section 19.2: pages 650 - 658

Section 19.3: pages 659 -668

Chapter 20: Section 20.1: pages 674 - 675

### References and Notes

Referring to Section 19.2, pages 650 - 658 write answers for questions 6.1 - 6.3 ▶▶

In addition to the terms for which you are writing definitions, you should know how to use the following terms correctly as you complete the writing for this section:

- paleontology
- S.S. Beagle
- Galapagos Islands

### Viewing:

If you have internet access, go to <http://www.mcgrawhill.ca/school/booksites/biology/student+resources/toc/unit+7+evolution/chapter+19+introducing+evolution/cool+stuff+to+see+and+do/movie+species+diversity.php> and view the movie "Galápagos Species Diversity".

### Work to Submit

#### Writing:

6.1 (a) What is meant by the idea of "use and disuse"?

(b) Describe Lamarck's theory of inheritance of acquired traits.

6.2 What are the 2 main ideas expressed by Darwin in his book, "The Origin of the Species"?

6.3 What are the factors identified by Charles Darwin that govern natural selection?

## Unit 6 - Evolutionary Change: Mechanisms of Evolution

### References and Notes

*Referring to Section 20.1, pages 674-675, write answers for questions 6.4 - 6.5* ▶▶

*Referring to Section 19.3, write answers for questions 6.6 - 6.10* ▶▶

*In addition to the terms for which you are writing definitions, you should know how to use the following terms correctly as you complete the writing for this section:*

- *transitional fossils*
- *endemic*
- *genetic structure*
- *Hardy - Wienberg equilibrium*
- *artificial selection*

*See your instructor to discuss which questions you should do from the "Section Review" and/or "Chapter Review" and any other work that may be required for this unit.*

### Work to Submit

#### Writing:

- 6.4 Why was it difficult for Darwin to explain the mechanism of natural selection?
- 6.5 How did the work of Gregor Mendel support the idea of natural selection?
- 6.6 (a) What is meant by fossil record?  
(b) Explain how the fossil record provides evidence that supports the modern theory of evolution
- 6.7 (a) What is meant by biogeography?  
(b) Explain how biogeography provides evidence that supports the modern theory of evolution.
- 6.8 Explain what is meant by each of the following anatomy terms and describe, using an example, how they support the modern theory of evolution:
- (i) homologous structures
  - (ii) analogous structures
  - (iii) vestigial structures
- 6.9 (a) What is meant by embryology?  
(b) Explain how embryology provides evidence that supports the modern theory of evolution
- 6.10 Explain how the study of molecular biology provides evidence that supports the modern theory of evolution.

## Unit 7 - Evolutionary Change: Adaptation and Speciation

To fulfill the objectives of this unit, students should complete the following:

**Reading for this unit:** *Biology*  
Chapter 21: Section 21.2: pages 708 - 709  
Section 21.3: pages 720 - 723

### References and Notes

*Referring to Section 21.2, pages 708 - 709, write answers for questions 7.1 - 7.3* ▶▶

*Referring to Section 21.3, pages 720 - 723, write answers for questions 7.4 - 7.6* ▶▶

*See your instructor to discuss which questions you should do from the "Section Review" and/or "Chapter Review" and any other work that may be required for this unit.*

### Work to Submit

#### Writing:

- 7.1 Define biological species.
- 7.2 (a) Explain what is meant by speciation.  
(b) Describe the two general pathways (transformation and divergence) that lead to the formation of a new species.
- 7.3 Name and briefly describe the 2 types of barriers that prevent genetic mixing between species.
- 7.4 Explain and give an example of adaptive radiation.
- 7.5 Explain the difference between divergent and convergent evolution and give an example of each.
- 7.6 Explain and give an example of coevolution.





# **Appendix A**

## **Assignments**



# Assignment 1

## Genetic Disorders

1. Explain what is meant by each of the following types of chromosome mutations:
  - (i) deletion
  - (ii) duplication
  - (iii) inversion
  - (iv) translocation
  - (v) nondisjunction (monosomy, trisomy)
  
2. Give the genetic cause and a brief description of the symptoms for each of the following human genetic diseases:
  - (i) Down syndrome
  - (ii) Turner syndrome
  - (iii) Klinefelter syndrome (XXY syndrome)
  - (iv) Jacobs syndrome (XYY syndrome)

## Assignment 2

### Genetics: Implications

1.
  - (a) What is meant by autosomal recessive inheritance?
  - (b) Give an example of an autosomal recessive disorder and how it affects the individual who has it.
2.
  - (a) Give an example of a co-dominant genetic disorder.
  - (b) Explain how this disorder affects the individual.
3.
  - (a) Give an example of x-linked recessive inheritance.
  - (b) Explain why x-linked recessive disorders are more common in males than females.
4. Describe what is done by a genetic counselor and why the job of a genetic counselor is important.
5. Describe the following 2 methods of prenatal diagnosis:
  - (i) amniocentesis
  - (ii) fetoscopy
6. What is the Human Genome Project?
7. What were the 2 major initial findings of the project?

# **Appendix B**

## **Lab**



## Karyotyping

<b>Introduction</b>	<p>You are a genetic counselor whose job is to discuss with expecting parents any genetic disorder that may affect their child. Currently, you are working with two couples. The two expectant mothers are over thirty-five and are concerned that their unborn children may have chromosomal abnormalities. You have been given a chromosome spread of each of the children. For each couple, you must construct and analyze a karyotype. In addition, you will be expected to give each couple a brief explanation of the test results, including the characteristics of any genetic disorder that may affect their unborn child.</p>
<b>Purpose</b>	<p>To connect and analyze several karyotypes.</p>
<b>Materials</b>	<p>Glue (1)                      Chromosome Spread Sheets (2) Ruler (1)                    Karyotype Templates #'s 1 and 2 Scissors (1 pair)</p>
<b>Procedure</b>	<ol style="list-style-type: none"><li>1. Obtain two different chromosome spread sheets from your teacher.</li><li>2. Cut out the chromosomes of one of the chromosome spread sheets.</li><li>3. Arrange the chromosomes into 22 pairs on the karyotype template. The chromosomes of each pair should be the same length (use a ruler!) and have the same centromere position. They should also have similar banding patterns. The two remaining chromosomes are the sex chromosomes. Since the X and Y chromosomes are nonhomologous, they will not have similar lengths, centromere positions or banding patterns. (Refer to the normal human karyotype.)</li><li>4. Now, place the chromosomes in order, with the longest pair at position 1, the shortest at position 22, and the sex chromosomes at position 23.</li><li>5. Finally, glue each chromosome into position. Be sure to label your karyotype according to the chromosome spread you were given.</li><li>6. Use your constructed karyotype # 1 to answer the analysis question 1.</li></ol>

**Analysis**

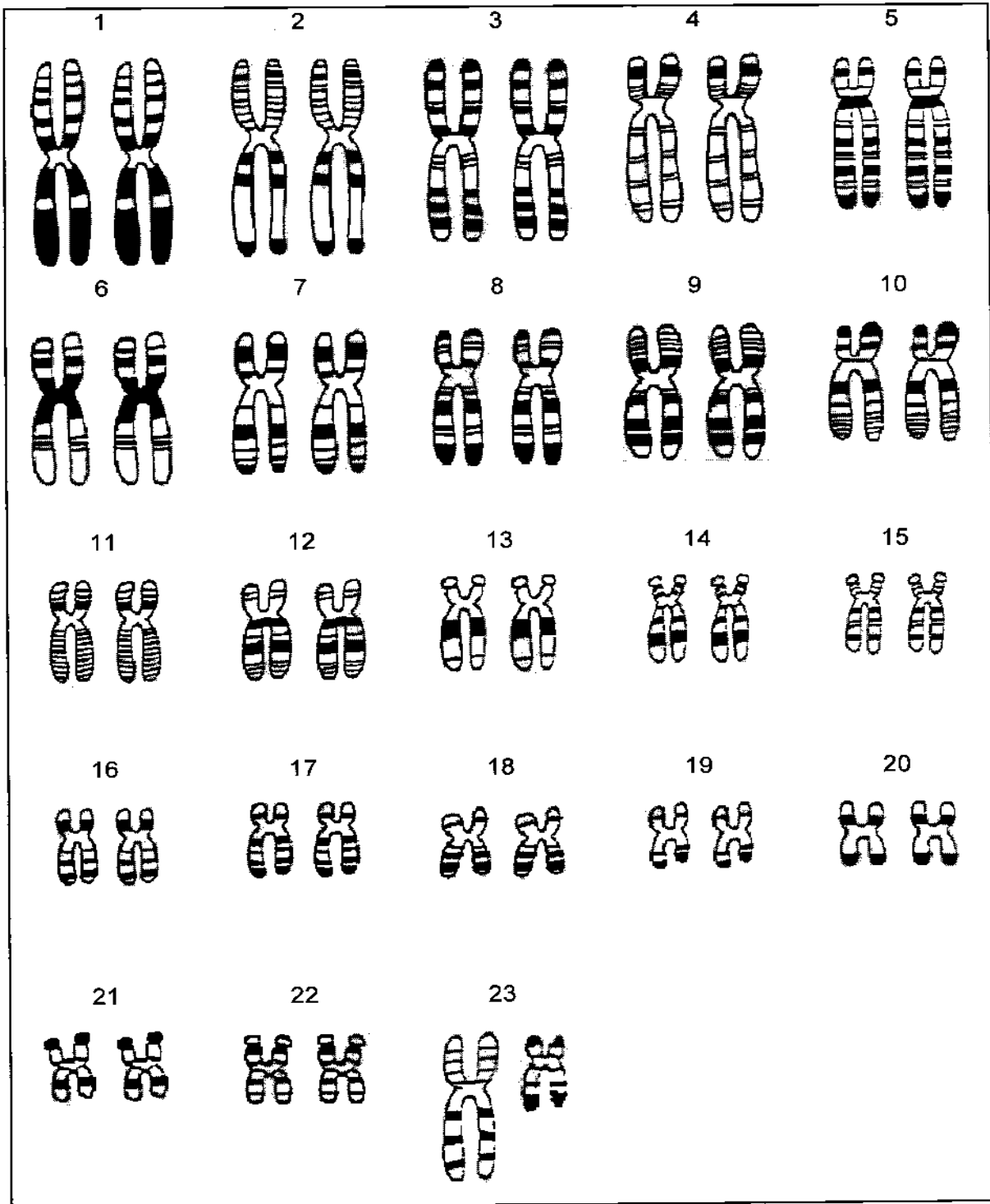
7. Repeat steps 1 to 5 for your second chromosome spread sheet.
8. Use your constructed karyotype #2 to answer the analysis question 2.
1. Analyze karyotype #1 to determine if a chromosomal abnormality exists.
  - a) Will the child have a genetic disorder?
  - b) Explain the reason for your answer.
  - c) Using the student chart, determine which genetic complication will affect the child.
2. Analyze karyotype #2 to determine if a chromosomal abnormality exists.
  - a) Will the child have a genetic disorder?
  - b) Explain the reason for your answer.
  - c) Using the student chart, determine which genetic complication will affect the child.



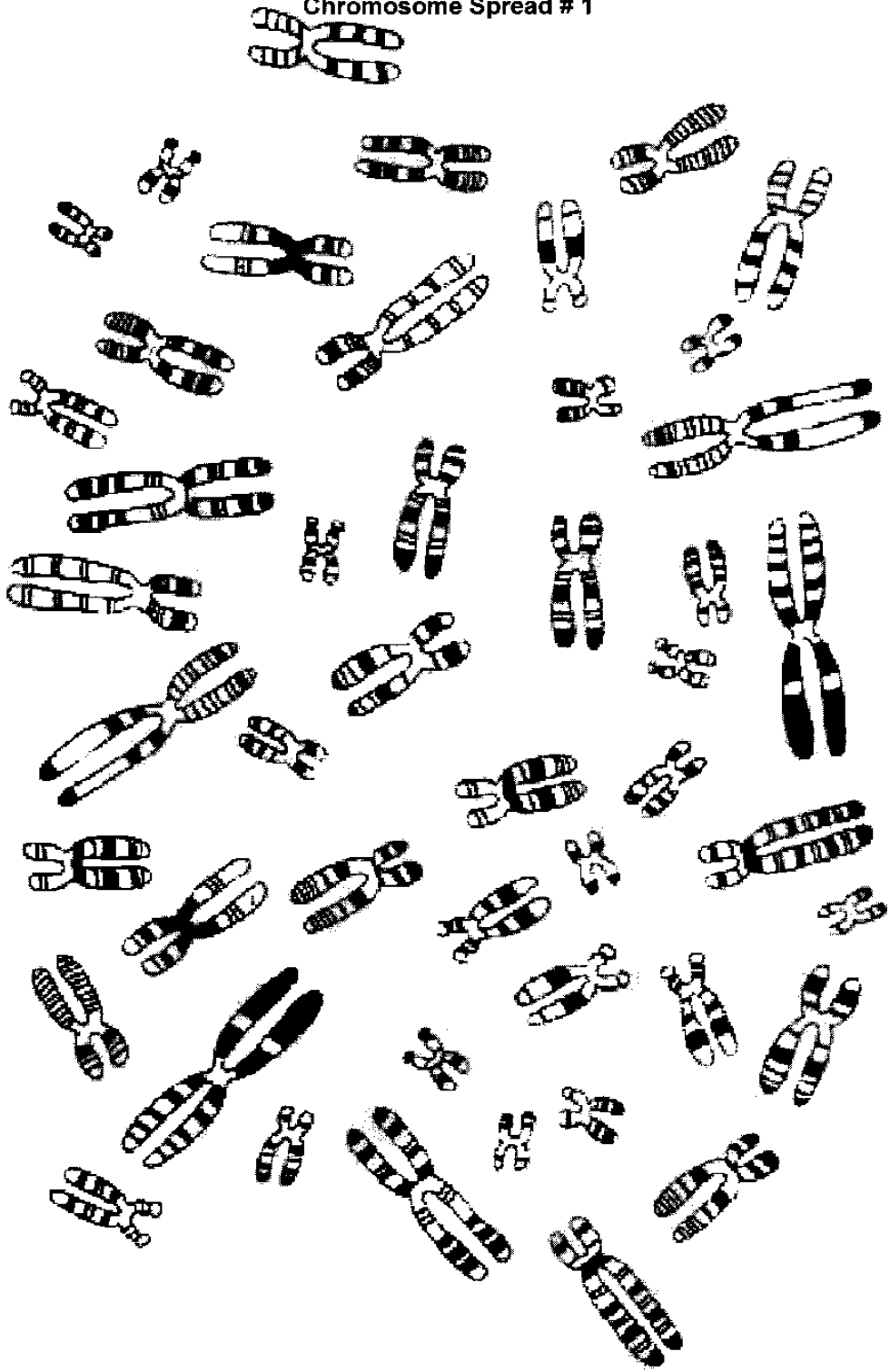
## Genetic Disorders

Genetic Disorder	Chromosome Affected	Description of Disorder
Down Syndrome	# 21	47 chromosomes, mild to severe developmental disabilities, almond - shaped eyes, large tongue, prone to heart defects and respiratory problems.
Turner Syndrome	Single X in female (XO)	45 chromosomes, female lacking an X chromosome, normal in childhood, normal intelligence, fails to develop secondary sex characteristics and remains infertile.
Klinefelter Syndrome	Extra X in Male (XXY)	47 chromosomes, male with an additional X chromosome, usually normal in appearance, normal intelligence, tall, underdeveloped testes, sterile, may also cause female characteristics (breast development, feminine body shape).
Jacobs Syndrome	Extra Y in Male (XYY)	47 chromosomes, male with an additional Y chromosome, low mental ability, normal in appearance.
Triple X Syndrome	Extra X in Female (XXX)	47 chromosomes, female with an extra X chromosome, normal intelligence, normal in appearance, may be sterile.

### Normal Human Karyotype

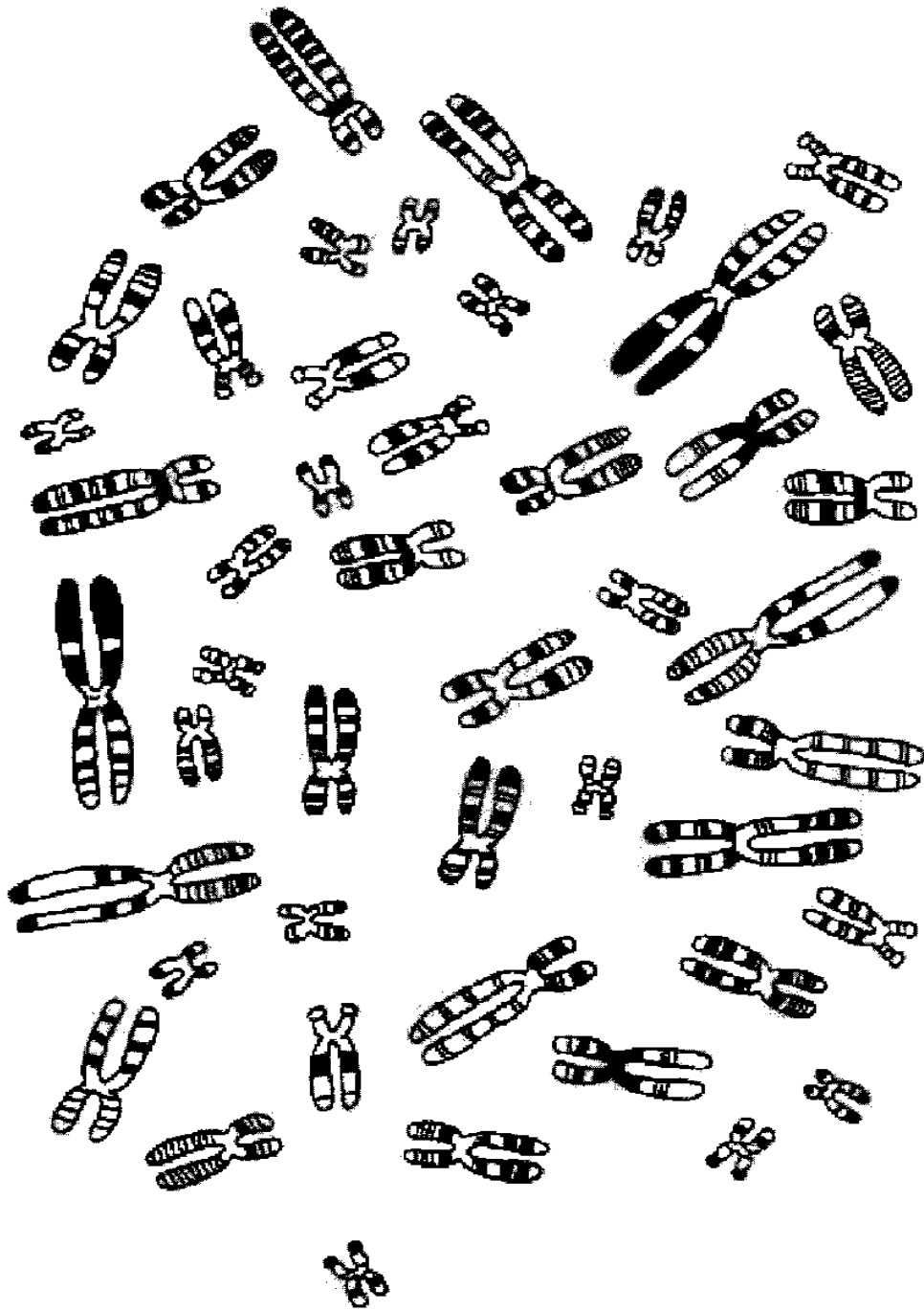


Chromosome Spread # 1



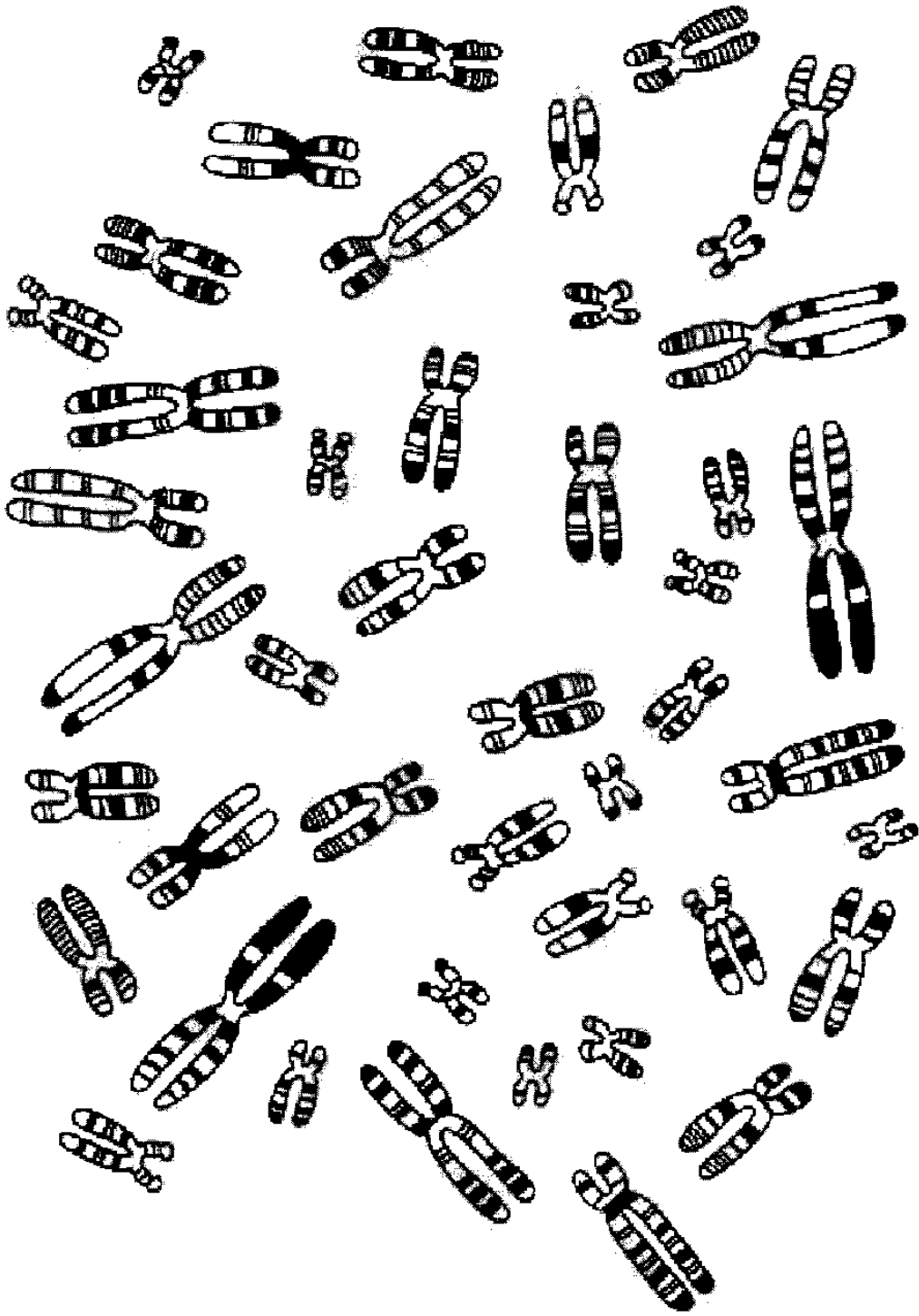


Chromosome Spread # 2





Chromosome Spread # 3







***Karyotype # 1***

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1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23		

**Karyotype # 2**

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1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23		

