Basic Genetics

CREDIT HOURS: 3
LEVEL: LOWER

EXAM CODE: 250
CATALOG NUMBER: BIOX250

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Prefering for the Exam

Before You Choose This UExcel Exam

Uses for the Examination

• Excelsior College, the test developer, recommends granting three (3) semester hours of lower-level undergraduate credit to students who receive a letter grade of C or higher on this examination.

• Other colleges and universities also recognize this exam as a basis for granting credit or advanced standing.

• Individual institutions set their own policies for the amount of credit awarded and the minimum acceptable grade.

Exam-takers who have applied to Excelsior College should ask their academic advisor where this exam fits within their degree program.

Exam-takers not enrolled in an Excelsior College degree program should check with the institution from which they wish to receive credit to determine whether credit will be granted and/or to find out the minimum grade required for credit. Those who intend to enroll at Excelsior College should ask an admissions counselor where this exam fits within their intended degree program.

Examination Length and Scoring

The examination consists of approximately 100 questions, most of which are multiple choice; for samples of all the item types on this exam, see the sample items in the back of this guide. Some items are unscored, pretest items. The pretest items are embedded throughout the exam and are indistinguishable from the scored items. You will have two (2) hours to complete the examination. Your score will be reported as a letter grade.

UExcel Exam Resources

Excelsior College Bookstore

The Excelsior College Bookstore offers recommended textbooks and other resources to help you prepare for UExcel exams.

The bookstore is available online at (login required): www.excelsior.edu/bookstore

UExcel Practice Exams

The official UExcel practice exams are highly recommended as part of your study plan. Once you register for your UExcel exam, you are eligible to purchase the corresponding practice exam, which can be taken using any computer with a supported Web browser. Each practice exam includes two forms that you may take within a 180-day period.

Excelsior College Library

Enrolled Excelsior College students can access millions of authoritative resources online through the Excelsior College Library. Created through our partnership with the Sheridan Libraries of The Johns Hopkins University, the library provides access to journal articles, books, websites, databases, reference services, and many other resources. Special library
pages relate to the nursing degree exams and other selected exams. To access it, visit www.excelsior.edu/library (login is required).

Our library provides:

- 24/7 availability
- The world’s most current authoritative resources
- Help and support from staff librarians

**Online Tutoring**

Excelsior College offers online tutoring through SMARTTHINKING™ to connect with tutors who have been trained in a variety of academic subjects. To access SMARTTHINKING, go to www.excelsior.edu/smarthinking. Once there, you may download a copy of the SMARTTHINKING Student Handbook as a PDF.

**Preparing for UExcel Exams**

**Take Charge of Your Own Learning**

At Excelsior College, independent, self-directed study supported by resources we help you find is not a new concept. We have always stressed to exam takers that they are acting as their own teacher, and that they should spend as much time studying for an exam as they would spend in a classroom and on homework for a corresponding college course in the same subject area.

Begin by studying the content outline contained in this content guide, at its most detailed level. You will see exactly which topics are covered, and where chapters on those topics can be found in the Recommended Resources. You will see exactly where you might need to augment your knowledge or change your approach.

The content outline, along with the Learning Outcomes for this exam and recommended textbooks, will serve as your primary resources.

**How Long Will It Take Me to Study?**

A UExcel exam enables you to show that you’ve learned material comparable to one or more 15-week college-level courses. As an independent learner, you should study and review as much as you would for a college course. For a 3-credit course in a subject they don’t know, most students would be expected to study nine hours per week for 15 weeks, for a total of 135 hours.

**Study Tips**

Become an active user of the resource materials. Aim for understanding rather than memorization. The more active you are when you study, the more likely you will be to retain, understand, and apply the information.

The following techniques are generally considered to be active learning:

- **preview or survey** each chapter
- **highlight or underline text** you believe is important
- **write questions or comments** in the margins
- **practice re-stating content** in your own words
- **relate what you are reading** to the chapter title, section headings, and other organizing elements of the textbook
- **find ways to engage** your eyes, your ears, and your muscles, as well as your brain, in your studies
- **study with a partner or a small group** (if you are an enrolled student, search for partners on MyExcelsior Community)
- **prepare your review notes** as flashcards or create recordings that you can use while commuting or exercising

When you feel confident that you understand a content area, review what you have learned. Take a second look at the material to evaluate your understanding. If you have a study partner, the two of you can review by explaining the content to each other or writing test questions for each other to answer. Review questions from textbook chapters may be helpful for partner or individual study, as well.

**Using UExcel Practice Exams**

We recommend taking the first form of the practice exam when you begin studying, to see how much you already know. After taking the first practice exam, check your performance on each question and find out why your answer was right or wrong. This feedback will help you improve your knowledge of the subject and identify areas of weakness that you should address before taking the exam. Take the second form of the
practice exam after you have finished studying. Analyze your results to identify the areas that you still need to review.

Although there is no guarantee, our research suggests that students who do well on the practice exams are more likely to pass the actual exam than those who do not do well (or do not take advantage of this opportunity).

**About Test Preparation Services**

Preparation for UExcel® exams and Excelsior College® Examinations, though based on independent study, is supported by Excelsior College with a comprehensive set of exam learning resources and services designed to help you succeed. These learning resources are prepared by Excelsior College so you can be assured that they are current and cover the content you are expected to master for the exams. These resources, and your desire to learn, are usually all that you will need to succeed.

There are test-preparation companies that will offer to help you study for our examinations. Some may imply a relationship with Excelsior College and/or make claims that their products and services are all that you need to prepare for our examinations.

Excelsior College is not affiliated with any test preparation firm and does not endorse the products or services of these companies. No test preparation vendor is authorized to provide admissions counseling or academic advising services, or to collect any payments, on behalf of Excelsior College. Excelsior College does not send authorized representatives to a student’s home nor does it review the materials provided by test preparation companies for content or compatibility with Excelsior College examinations.

To help you become a well-informed consumer, we suggest that before you make any purchase decision regarding study materials provided by organizations other than Excelsior College, you consider the points outlined on our website at [www.excelsior.edu/testprep](http://www.excelsior.edu/testprep).

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**Preparing for This Exam**

**Prior Knowledge**

A familiarity with introductory biology, general chemistry, and algebra is assumed.

**Using the Content Outline**

Each content area in the outline includes (1) the recommended minimum hours of study to devote to that content area and (2) the most important sections of the recommended resources for that area. These annotations are not intended to be comprehensive. You may need to refer to other chapters in the recommended textbooks. Chapter numbers and titles may differ in other editions.

This content outline contains examples of the types of information you should study. Although these examples are numerous, do not assume that everything on the exam will come from these examples. Conversely, do not expect that every detail you study will appear on the exam. Any exam is only a broad sample of all the questions that could be asked about the subject matter.

**Using the Sample Questions and Rationales**

Each content guide provides sample questions to illustrate those typically found on the exam. These questions are intended to give you an idea of the level of knowledge expected and the way questions are typically phrased. The sample questions do not sample the entire content of the exam and are not intended to serve as an entire practice test.

**Recommended Resources for the UExcel Exam in Basic Genetics**

The resources and materials listed below were used by the examination development committee to verify all the questions on the exam. Excelsior College recommends you use these resources as the most appropriate information when ordering textbooks.
from the college’s bookstore (see page 1 of this content guide). You should allow ample time to obtain resources and to study sufficiently before taking the exam, so plan appropriately and systematically.

A word about textbook editions: Textbook editions listed in the UExcel content guides may not be the same as those listed in the bookstore. Textbook editions may not exactly match up in terms of table of contents and organization, depending upon the edition. However, our team of exam developers checks exam content against every new textbook edition to verify that all subject areas tested in the exam are still adequately available in the study materials. If needed, exam developers will list supplemental resources to ensure that all topics in the exam are still sufficiently covered. Public libraries may have the textbooks you need, or may be able to obtain them for you through interlibrary loan to reduce textbook costs. You may also consider financial aid, if you qualify, to further help defray the steep cost of textbooks. A section on OER has been included in this guide to help you locate additional resources to augment your study.

**Textbook**

This textbook was used by the examination development committee to verify all questions on the exam.

These study materials may be purchased from the Excelsior College Bookstore (login required).


**Reducing Textbook Costs**

Many students know it is less expensive to buy a used textbook, and buying a previous edition is also an option. The Excelsior College bookstore includes a buyback feature and a used book marketplace, as well as the ability to rent digital versions of textbooks for as long as students need them. Students are encouraged to explore these and the many other opportunities available online to help defray textbook costs.

**A Word About Open Educational Resources**

Open educational resources (OER) are educational materials available for study at no cost on the Web. Some OER are available for anyone to access any time. Others, such as Massive Open Online Courses (MOOCs), require sign-up and are only available during certain windows. Please note that some MOOC providers offer certificates of completion or other products or services for a fee. No MOOC or other OER is a complete substitute for the content guide and officially Recommended Resources listed here in this content guide. However, by definition, MOOCs are essentially free of charge and include access to a main body of learning materials that may help you in your learning.

Being an independent learner preparing for credit by exam, you may not need any of the fee-based options that are offered elsewhere online. But if you are looking for a coherent academic course for self-study, lectures on specific topics, or audio or visual materials that fit your learning style better than print materials alone, a MOOC or other type of OER may be your answer. Keep in mind that none of these OER were designed by Excelsior, nor are they guaranteed to match the exam content outlines completely. They are simply another tool available in your study kit.

We highly encourage using the Recommended Resources. In the content outline, you will see that the topics in the exam are referenced to specific portions of recommended textbooks. Using OER alone will not ensure you’ve completely covered the content in the exam, or it may not cover some topics in sufficient-enough depth without the use of the formal, recommended textbooks.

If the OER course you choose does not include a textbook for reference and you do not have significant practical theory-based experience in the field of study, use a college textbook to ensure adequate preparation for the exam, and use the exam’s content outline as a guide.

Combined with comparable college textbooks, OER provides you with a variety of choices in knowledge sources and learning experiences, to enhance your understanding of the subject matter.

**Choosing Open Educational Resources**

Most sites for university-based OER can be searched through www.ocwconsortium.org and/or www.oercommons.org.

Sites that specialize in Web courses designed by college professors under contract with the website sponsor, rather than in Web versions of existing college courses, include:
We have included specific courses that cover material for one or more UExcel® exams from the sites in the listings above. It's worth checking these sites frequently to see if new courses have been added that may be more appropriate or may cover an exam topic not currently listed.

In addition, sites like Khan Academy (www.khanacademy.com) and iTunes U feature relatively brief lessons on very specific topics rather than full courses. Full courses are also available on iTunes U (http://www.apple.com/education/ipad/itunes-u/). We have chosen a few courses and collections for this listing.

**Other Online Resources**

This section of the OER Guide is provided to allow learners to independently search for resources. Send an e-mail to OER@excelsior.edu if you have questions about a resource’s credibility.

**Open Online Textbooks**

Boundless open textbooks
https://www.boundless.com/open-textbooks/

BookBoon
http://bookboon.com/en/textbooks-ebooks

Flatworld Knowledge
http://catalog.flatworldknowledge.com/#our-catalog

**College Readiness**

Khan Academy
http://www.khanacademy.org/

Hippocampus
http://www.hippocampus.org/

Open Course Library
http://opencourselibrary.org/collg-110-college-success-course/

**Study Aids**

Education Portal
http://education-portal.com/

Khan Academy
http://www.khanacademy.org/

Annenberg Learner
http://www.learner.org/
General Description of the Examination

The UExcel Basic Genetics examination is based on material typically taught in a one-semester, three-credit, lower-level course in genetics for non-biology majors.

The examination measures understanding of basic concepts and terminology of transmission, molecular, and population genetics. The exam also measures the ability to apply this knowledge to solving problems in genetics, as well as an understanding of the societal implications of genetic technologies.

Those beginning to study for this exam should be familiar with introductory biology, general chemistry, and algebra.

Learning Outcomes

After you have successfully worked your way through the recommended study materials, you should be able to demonstrate the following learning outcomes:

1. Explain the details of Mendelian genetics, its extensions and modifications.
2. Explain the central dogma of molecular genetics, gene regulation, and protein structure/function.
3. Compare/contrast the role of nature vs. nurture in the development of complex traits.
4. Demonstrate critical understanding of scientific method and skills in problem solving and quantitative analysis.
5. Discuss genetic technologies and their implications to human health, social, and environmental issues.
Content Outline

The content outline describes the various areas of the test, similar to the way a syllabus outlines a course. To fully prepare requires self-direction and discipline. Study involves careful reading, reflection, and systematic review.

The major content areas on the Basic Genetics examination, the percent of the examination, and the hours to devote to each content area are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Percent of the Examination</th>
<th>Hours of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Molecular and Chromosomal Basis of Inheritance</td>
<td>15%</td>
<td>21</td>
</tr>
<tr>
<td>II. Transmission/Mendelian Genetics</td>
<td>25%</td>
<td>34</td>
</tr>
<tr>
<td>III. Genotype to Phenotype</td>
<td>25%</td>
<td>34</td>
</tr>
<tr>
<td>IV. Mutation, Variation, and Evolution</td>
<td>20%</td>
<td>27</td>
</tr>
<tr>
<td>V. Biotechnology and Societal Implications</td>
<td>15%</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Occasionally, examples will be listed for a content topic to help clarify that topic. However, the content of the examination is not limited to the specific examples given.

I. Molecular and Chromosomal Basis of Inheritance

15% PERCENT OF EXAM | 21 HOURS OF STUDY

Klug (2013)

- Ch. 1, An Introduction to Genetics
- Ch. 2, Mitosis and Meiosis
- Ch. 10, DNA Structure and Analysis
- Ch. 11, DNA Replication and Synthesis
- Ch. 13, Translation and Proteins
- Ch. 17, Chromosome Structure and DNA Sequence Organization

A. Chromosome theory of inheritance

B. Structure

1. DNA
2. RNA
3. Protein
4. Chromosome

C. DNA synthesis

D. Mitosis and meiosis

II. Transmission/Mendelian Genetics

25% PERCENT OF EXAM | 34 HOURS OF STUDY

Klug

- Ch. 3, Mendelian Genetics
- Ch. 4, Modification of Mendelian Ratios
- Ch. 5, Sex Determination and Sex Chromosomes
- Ch. 8, Linkage and Chromosome Mapping in Eukaryotes
A. Dominance/recessiveness (Mendel’s second postulate)

B. Mendel’s Laws
1. Law of Segregation (Mendel’s third postulate)
2. Law of Independent Assortment (Mendel’s fourth postulate)
3. Punnett square
4. Chi-square test

C. Extensions and modifications
1. Codominance and incomplete dominance
2. Multiple alleles
3. Lethal alleles
4. Genetic interactions
5. Sex determination
6. Sex linkage
7. Penetrance and expressivity

D. Mapping
1. Complementation tests
2. Linkage and chromosome mapping
3. Pedigree analysis

IV. Genotype to Phenotype

A. Central dogma
1. Transcription and its regulation
   a. Prokaryotic/eukaryotic gene structure
   b. Prokaryotic/eukaryotic transcription
   c. Prokaryotic/eukaryotic transcriptional regulation

B. Epigenetics (methylation and imprinting)

C. Developmental genetics
1. Maternal effect genes
2. Zygotic genes
   a. Gap
   b. Pair-rule
   c. Segment polarity
   d. Homeotic

IV. Mutation, Variation, and Evolution

A. DNA mutation and repair
1. Types of mutations
   a. DNA
   b. Chromosome
2. Mutagens
3. Mechanism of DNA repair

B. Population genetics
1. Hardy-Weinberg law
2. Natural selection
3. Inbreeding

C. Quantitative genetics
1. Polygenic inheritance
2. Partitioning phenotypic variance and heritability
3. Genotype-by-environment interactions

V. Biotechnology and Societal Implications

| 15 PERCENT OF EXAM | 21 HOURS OF STUDY |

Klug

Ch. 3, Mendelian Genetics
Ch. 14, Gene Mutation, DNA Repair, and Transposable Elements
Ch. 15, Regulation of Gene Expression
Ch. 21, The Genetic Basis of Cancer
Ch. 16, Recombinant DNA Technology
Ch. 18, Genomics and Proteomics
Ch. 19, Biotechnology and Its Implications for Society
Ch. 20, Genes and Development

A. Human diseases
1. Cell cycle control and cancer
2. Stem cells
3. Tay-Sachs disease
4. Hemophilia

B. Recombinant DNA technology
1. Cloning
2. Polymerase chain reaction (PCR)
3. Transgenics

C. Genomics and proteomics
1. Human Genome Project
2. Comparative genomics

D. Applications and ethics
1. Genetically modified food
2. Genetic testing
Sample Questions

The sample questions give you an idea of the level of knowledge expected in the exam and how questions are typically phrased. They are not representative of the entire content of the exam and are not intended to serve as a practice test.

Rationales for the questions can be found on pages 14–18 of this guide. In that section, the correct answer is identified and each answer is explained. The number in parentheses at the beginning of each rationale refers to the corresponding section of the content outline. For any questions you answer incorrectly, return to that section of the content outline for further study.

1. Which statement is a part of the chromosome theory of inheritance?
   1) The molecule of inheritance is DNA.
   2) Genes occur in pairs, as chromosomes do.
   3) The chromosomes of an organism are of equal lengths.
   4) Chromosomal mutations give rise to variations in living organisms.

2. The sequence of one strand of DNA is 5’–GCTAG–3’. What are the sequence and the polarity of the complementary strand?
   1) 5’–CGATC–3’
   2) 5’–CGAUC–3’
   3) 5’–CUAGC–3’
   4) 5’–CTAGC–3’

3. What is the function of a primase during DNA replication?
   During DNA replication, the primase
   1) adds ribonucleotide to a free 5’ end of a polynucleotide.
   2) adds deoxyribonucleotide to a free 3’ end of a growing polynucleotide.
   3) adds ribonucleotide to a nonfree 3’ portion of DNA to initiate replication.
   4) proofreads activities to remove incorrectly paired nucleotides in a growing chain.

4. If a diploid organism has 12 chromosomes in its somatic cells, how many chromosomes does it have in these cells during prophase II of meiosis?
   1) 3
   2) 6
   3) 12
   4) 24

5. Assume T (tall) is dominant to t (short). In the cross, TT × Tt, what proportion of the offspring will be short?
   1) 0%
   2) 25%
   3) 50%
   4) 100%

6. Which ratio represents the result of Mendel’s monohybrid cross experiment?
   1) 3:1 genotypic ratio in the F2 generation
   2) 3:1 genotypic ratio in the F1 generation
   3) 3:1 phenotypic ratio in the F1 generation
   4) 3:1 phenotypic ratio in the F2 generation
7. When two heterozygous yellow mice are crossed, the progeny are produced in a ratio of 2 yellow to 1 agouti. Which mechanism best explains this outcome?
   1) epistasis
   2) lethal allele
   3) variable expressivity
   4) incomplete penetrance

8. What distinguishes sex-linked genes from genes that are located on autosomes?
   Sex-linked genes
   1) are only transmitted through the female.
   2) are phenotypically expressed only in males.
   3) may display a crisscross pattern of inheritance.
   4) are transmitted from one parent to all the same-sex offspring.

9. Two *Drosophila* strains that have a wingless mutant trait are crossed with each other. All of the progeny are wingless. However, if each of these strains is crossed to a wild-type strain, then all of the progeny are wild type. Which conclusion is consistent with these results?
   1) The mutant traits are epistatic to the wild-type trait.
   2) The mutant traits are dominant to the wild-type trait.
   3) The wingless strains had mutations in the same locus.
   4) The wingless strains had mutations in two different loci.

10. Base your answer on the figure below:

    A family has a history of a genetic disorder caused by a single gene. What best describes this disorder? (Select the 2 that apply.)
    1) autosomal
    2) dominant
    3) recessive
    4) sex-linked

11. Which eukaryotic gene sequences are typically transcribed and retained in mature mRNA?
    1) exons
    2) introns
    3) promoters
    4) TATA boxes

12. What is characteristic of the genetic code?
    The genetic code is
    1) species specific but not degenerate.
    2) species specific and degenerate.
    3) nearly universal but not degenerate.
    4) nearly universal and degenerate.

13. By which process does biological polymerization of amino acids result in polypeptide chains?
    1) phosphorylation
    2) replication
    3) transcription
    4) translation
14. Which outcome is most likely to occur when a eukaryotic gene becomes methylated?
   1) Expression of the gene will decrease.
   2) RNA polymerase will bind the promoter more efficiently.
   3) Transcription activators will bind the gene more efficiently.
   4) The chromosome the gene resides on will be inactivated.

15. What is the function of maternal effect genes in *Drosophila* development?
   Maternal effect genes establish
   1) segment polarity within the embryo.
   2) the anterior-posterior axis of the embryo.
   3) segmental boundaries within the embryo.
   4) the head, thoracic, and abdominal regions of the embryo.

16. What transcription factors are encoded in *Drosophila* genes to regulate the expression of segment polarity?
   1) gap genes
   2) *Hox* genes
   3) apoptosis genes
   4) pair-rule genes

17. Which type of mutation is most likely to result in a frameshift?
   1) insertion
   2) missense
   3) nonsense
   4) silent

18. What is the sequence of the following events in base excision repair (BER)?
   A: AP endonuclease recognizes lesion and nicks DNA strand.
   B: Uracil DNA glycosylase recognizes and excises incorrect base.
   C: DNA polymerase and DNA ligase fill gap.
   1) ABC
   2) BAC
   3) CBA
   4) BCA

19. Why is it rare for a natural population to completely conform to the Hardy-Weinberg model?
   Most populations
   1) are not infinitely large.
   2) are not under selection pressures.
   3) are not subject to evolutionary forces.
   4) are comprised of individuals that randomly mate.

20. What is the most common effect of inbreeding on fitness?
   1) decreased fitness due to the increased frequency of recessive alleles
   2) increased fitness due to the increased frequency of dominant alleles
   3) decreased fitness due to the increased frequency of dominant phenotypes
   4) decreased fitness due to the increased frequency of homozygous genotypes

21. What characterizes polygenic inheritance?
   Inheritance of
   1) quantitative traits that result from the expression of multiple genes
   2) qualitative traits determined by the expression of multiple alleles of a single gene
   3) qualitative traits that are produced by the combined effects of genetic and environmental factors
   4) quantitative traits that are produced by the combined effects of genetic and environmental factors

22. What does genotype-by-environment interaction most profoundly impact?
   1) genotypic variance
   2) phenotypic variance
   3) the expression of polygenic traits
   4) the expression of environmental attributes
23. Which condition is most essential for a DNA fragment to anneal with a vector, such as a plasmid?

The DNA fragment and the vector
1) must be of the same length.
2) must come from the same organism.
3) must have complementary sticky ends.
4) must both be single stranded along their entire length.

24. Ten copies of a double-stranded template DNA molecule undergo 20 cycles of polymerase chain reaction (PCR). What is the total number of resultant double-stranded DNA molecules?

1) 100
2) 200
3) $10 \times 2^{20}$
4) $20 \times 2^{20}$

25. Which trait has been genetically engineered into plants?

1) EPSP resistance
2) herbicide resistance
3) $\beta$-carotene resistance
4) $\beta$-galactosidase resistance
1. (IA)
   1) DNA is the molecule for inheritance, but this does not describe the chromosome theory of inheritance.
   2) The parallel between the behavior of genes and the behavior of the chromosomes as observed by Sutton and Boveri was discovered based on the behavior of homologous chromosomes and a pair of genes, as observed by Mendel.
   3) A pair of homologous chromosomes are equal in length, but not equal in length with other chromosomes.
   4) Mutations do lead to variations, but this is not part of the original chromosome theory of inheritance.

2. (IB1)
   1) The sequence is correct but the polarity is reversed.
   2) The sequence would be correct for a complementary RNA molecule but not the other strand of DNA. In addition, the polarity is reversed.
   3) The sequence would be correct for a complementary RNA molecule but not the other strand of DNA, although the polarity is correct.
   *4) Both the sequence and the polarity are correct.

3. (IC)
   1) Nucleotides are added to the 3’ end, not to the 5’ end, so that polynucleotide chains are always built in the 5’–3’ direction.
   2) Primase, being a form of RNA polymerase, does not build deoxyribonucleotides by ribonucleotides.
   *3) Primase is a form of RNA polymerase that initiates replication by forming a short segment of RNA, to which the DNA polymerase adds deoxyribonucleotides.
   4) Proofreading is not a function of primase, but is carried out by DNA polymerase.

4. (ID)
   *1) Reductinal division during meiosis I halves the number of chromosomes, and there is no further reductional division.
   2) At prophase II of meiosis, the reductional division has already occurred, and the cells have half the number of chromosomes.
   3) There are 12 chromatids, but only 6 chromosomes.
   4) DNA replication during meiosis I does not increase the number of chromosomes in the daughter cells.
5. (IIA, IIB1)
   *1) The TT parent generates only T-containing gametes. The Tt parent generates T- or t-containing gametes equally. The combination of the gametes results in offspring being either TT or Tt, both of which would be tall, and neither short.
   
   2) See 1).
   3) See 1).
   4) See 1).

6. (IIB3)
   1) In the F2, the genotypic ratio is 1:2:1.
   2) In the F1, there is only one genotype.
   3) In the F1, there is only one phenotype.
   *4) In the F2, the phenotypic ratio is 3:1.

7. (IIC3)
   1) Epistasis causes ratios other than from 2:1.
   *2) In mice, AY is dominant to A in coat color and AAY and AAY are yellow and AA is agouti. But AYAY is also recessive lethal (so such mice won’t survive it). When two heterozygous yellow mice are crossed, AAY \times AAY produces \( \frac{1}{4} AA, \frac{1}{2} AAY, \) and \( \frac{1}{4} AYAY \) which dies. This leaves us with one of the remaining three-quarters agouti and two of the three-quarters yellow mice. Adjusting these to four quarters, this is a ratio of 2 yellow to 1 agouti. So the modified segregation ratio is caused by lethal allele.
   3) Variable expressivity causes variation in phenotype which may lead to phenotypes other than yellow and agouti.
   4) Incomplete penetrance does not usually cause 2:1 segregation.

8. (IIC6)
   1) The male may transmit sex-linked genes to his daughters.
   2) A female with two copies of a recessive sex-linked allele will display the trait.
   *3) Sex-linked genes display a crisscross pattern of inheritance since they are frequently transmitted from carrier mothers who do not display the trait to their sons. Alternatively, the trait may be transmitted from the father to daughter via the X chromosome.
   4) Sex-linked genes are transmitted via the X chromosome; no father to son transmission occurs.

9. (IID1)
   1) If epistasis were occurring, then one of the crosses to the wild-type strain would have masked the genotype of the other locus and yielded wingless Drosophila. Also see 4).
   2) Crosses between each wingless strain and wild-type flies yielded wild-type offspring. Therefore, both mutations are recessive.
   *3) Complementation generally fails to occur if the two strains have mutations in the same gene.
   4) Complementation generally occurs if the two strains have mutations in different genes.

10. (IID3)
    *1) This disorder must be autosomal because the affected female’s father is not affected. See 3).
    2) This disorder cannot be dominant because the affected female has two unaffected parents.
    *3) This disorder must be recessive because the affected female has two unaffected parents.
    4) This disorder cannot be sex linked because the affected female’s father is not affected. If it were sex linked he would need to have the affected X chromosome to transmit to his daughter, and since the X chromosome is hemizygous in males, he would need to be affected.

*correct answer
11. (IIIA)
*1) Exons are transcribed DNA sequences. After transcription of eukaryotic genes, introns are removed (spliced) and exons are joined together, forming the mature mRNA.

2) Introns are intervening sequences that are spliced out of pre-mRNA, so they are not retained in the mature mRNA.

3) Promoters are sequences, usually upstream of genes, where RNA polymerase binds. Promoter sequences are not transcribed.

4) TATA boxes are sequences within eukaryotic promoters that are recognized by transcription factors. Since they reside in promoters, they are not transcribed.

12. (IIIA2a)
1) See 4).

2) The genetic code is highly conserved across most organisms.

3) Many amino acids are coded by multiple codons.

*4) The genetic code is highly conserved across most organisms and many amino acids are coded by multiple codons.

13. (IIIA2b)
1) This is the addition of phosphate groups.

2) This is the process of copying DNA.

3) This is the process of making RNA from DNA.

*4) Translation is the process of making proteins.

14. (IIIB)
*1) Methylation of one gene on a chromosome will not inactivate the entire chromosome. Several genes would need to become methylated for the chromosome to be inactive (for example: X chromosome inactivation).

2) Since methylation of genes inhibits transcription, activators are not likely to bind a gene that becomes methylated. Methylation is likely to inhibit transcription activators from binding.

3) Since methylation prevents transcription, RNA polymerase will not bind the promoter.

4) Methylation of eukaryotic genes is associated with decreases in transcription of the gene.

*correct answer

15. (IIIC1)
1) Segment polarity genes establish segment polarity within the embryo.

*2) Maternal effect genes establish the anterior-posterior polarity of the embryo.

3) The combined activity of the pair-rule genes establishes segmental boundaries within the embryo.

4) Gap genes establish the head, thoracic, and abdominal regions of the embryo.

16. (IIIC2b)
1) Transcription factors encoded by gap genes regulate expression of pair-rule genes.

2) Transcription factors encoded by Hox genes promote gene expression involved in cell division, cell adhesion, apoptosis, and cell migration.

3) Apoptotic genes, although actively involved in development, do not associate with any of these genes involved in embryogenesis, that is with gap, pair-rule, and segment polarity genes.

*4) Expression of segment polarity genes is controlled by transcription factors encoded by pair-rule genes.

17. (IVA1a)
*1) Insertions of nucleotides not in multiples of 3 result in a frameshift mutation.

2) A missense mutation causes an amino acid different from the original amino acid to be produced in the protein product.

3) A nonsense mutation results in a stop codon to terminate protein synthesis.

4) A silent mutation does not change the amino acid in the protein product nor does it shift the reading frame.
18. (IVA3)
1) Steps one and two are reversed in this sequence.
2) This is the correct sequence of events that excises a mismatched base and inserts a correct base by the action of DNA polymerase and ligase to repair the DNA molecule.
3) Steps one and three are reversed in this sequence and the activities of the AP endonuclease and DNA polymerase/ligase are mismatched.
4) Steps two and three are reversed in this sequence.

19. (IVB1)
1) Most populations are not large enough (infinitely large) to be unaffected by mutations, evolution, non-random mating, etc.
2) Most populations are under natural selection pressures.
3) Most populations are subject to evolutionary forces.
4) Most populations are not comprised of individuals that randomly mate.

20. (IVB3)
1) Inbreeding does not increase the frequency of recessive alleles.
2) Inbreeding does not affect the frequency of dominant alleles.
3) Inbreeding is not generally associated with an increased frequency of dominant genotypes, and this is not associated with decreased fitness.
4) The increased frequency of homozygous genotypes is associated with increased occurrence of deleterious recessive phenotypes that may cause decreased fitness.

21. (IVC1)
1) Polygenic inheritance involves the inheritance of quantitative traits that are the product of the action of multiple genes that each contribute quantitatively to gene expression.
2) Polygenic inheritance involves quantitative traits and is the product of multiple genes.
3) Polygenic inheritance involves quantitative traits and does not involve environmental factors associated with multifactorial inheritance.
4) Polygenic inheritance does not involve environmental factors associated with multifactorial inheritance.

22. (IVC3)
1) See 2).
2) Genotype-by-environment most profoundly affects phenotype.
3) The environmental parameters are not affected by this type of interaction.
4) Genotype-by-environment interactions are not directly linked to polygenic inheritance.

23. (VB1)
1) The fragment and the vector are usually of different lengths. The DNA fragment to be cloned is usually smaller than the vector.
2) The DNA fragment does not have to be from the same source as the vector. In fact, in most cases they are from different sources.
3) The ultimate requirement for annealing is the possession of sticky ends by both the DNA segment to be cloned and the vector that will act as its carrier. The sticky ends are generated by the same enzymes that recognize the identical restriction sites in both vector and gene fragment.
4) The fragment and the vector are single stranded only at the sticky ends, which are complementary to each other and will anneal.

*correct answer
24. (VB2)
   1) This answer results from multiplying 10 by 10.
   2) This answer results from multiplying 10 by 20.
   *3) **The correct calculation multiplies 10 × 220**
       Solution: (starting number of template molecules present) \(10 \times 2^{\text{# of PCR cycles}}\)
   4) This answer results from counting the number of strands, not double-stranded molecules

25. (VD1)
   1) EPSP synthase is the chloroplast enzyme inhibited by the herbicide glyphosate.
   *2) **Herbicide resistance has been genetically engineered** into major agricultural plants such as soybean and cotton which tolerate the herbicide glyphosate.
   3) \(\beta\)-carotene is vitamin A.
   4) \(\beta\)-galactosidase is a reporter gene commonly used in genetic engineering.
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