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КАФЕДРА ІНОЗЕМНИХ МОВ

АНГЛІЙСЬКА МОВА ДЛЯ СТУДЕНТІВ СПЕЦІАЛЬНОСТІ «БІОЛОГІЯ ТА БІОХІМІЯ».
Частина II

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Рецензенти:
кандидат педагогічних наук, доцент Кухта М.І.
кандидат

Мета методичних рекомендацій − забезпечити практичне оволодіння студентами лексичними та мовленнєвими моделями, необхідними для вільного спілкування англійською мовою за фахом. Матеріали методичних рекомендацій сприятимуть оволодінню навичками та вмінням читання, мовлення (діалогічного і монологічного) та письма на фахову тематику. Методичні рекомендації призначені для широкого кола читачів: слухачів курсів іноземних мов, студентів та аспірантів, викладачів вищих навчальних закладів.

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ПЕРЕДМОВА

З прискоренням глобалізації і поширенням міжнародних ділових зв'язків України з іншими державами на політичному та економічному рівнях зростає потреба у висококваліфікованих фахівцях, які здатні вільно володіти основами професійного іншомовного спілкування. У таких умовах важливим є усвідомлення майбутніми фахівцями різних галузей необхідності їх майбутніх зв'язків із міжнародним середовищем, а одним з першочергових завдань освіти стає якісна підготовка фахівців, здатних до успішної професійної діяльності в межах світової спільноти. В цьому контексті істотно змінюються вимоги до володіння іноземною мовою фахівцями всіх рівнів, першорядного значення набувають практичні навички, що передбачають знання ділової іноземної мови в усному та писемному мовленні, вміння використовувати іноземну мову у своїй професійній діяльності.

Пропоновані методичні рекомендації мають на меті ознайомити з основами іншомовного професійного спілкування, розширити словниковий запас за рахунок спеціальної лексики, виробити комунікативні навички мовлення, навички письма.

Методичні рекомендації складаються з тематичних розділів, кожен з яких містить 1) тексти інформативного характеру, які допоможуть орієнтуватися в певних ситуаціях професійної сфери, 2) лексичний матеріал з найчастіше вживаними мовленнєвими конструкціями відповідної тематики, які допоможуть у побудові діалогів та монологічних повідомлень та 3) систему вправ для успішного засвоєння та вдосконалення комунікативних навичок професійно орієнтованого спілкування.

CONTENTS

Unit 9. Cell Cycle

Cell cycle	Клітинний цикл
Interphase	Інтерфаза
Mitotic phase	Міотична фаза
Centriole	Центріоль
Cytoplasmic components	Компоненти цитоплазми
Mitotic spindle	Міотичне веретено
Cohesin protein	Когезиновий білок
Sister chromatid	Сестринська хроматида
Human somatic cell	Соматична клітина людини
Human gamete	Гамета людини
Mutated gene	Мутований ген
Altered version	Змінена версія

9.1 Cell Cycle

The **cell cycle** is an ordered series of events involving cell growth and cell division that produces two new daughter cells. Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth, DNA replication, and division that produces two identical (clone) cells. The cell cycle has two major phases: interphase and the mitotic phas. During **interphase**, the cell grows and DNA is replicated. During the **mitotic phase**, the replicated DNA and cytoplasmic contents are separated, and the cell divides.

9.2 Interphase

During interphase, the cell undergoes normal growth processes while also preparing for cell division. In order for a cell to move from interphase into the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called G_1, S, and G_2.

9.3 G_1 Phase (First Gap)

The first stage of interphase is called the **G_1 phase** (first gap) because, from a microscopic aspect, little change is visible. However, during the G_1 stage, the cell is quite active at the biochemical level. The cell is accumulating the building blocks of chromosomal DNA and the associated proteins as well as accumulating sufficient energy reserves to complete the task of replicating each chromosome in the nucleus.

9.4 S Phase (Synthesis of DNA)

Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration. In the **S phase**, DNA replication can proceed through the mechanisms that result in the formation of identical pairs of DNA molecules—sister chromatids—that are firmly attached to the centromeric region. The centrosome is duplicated during the S phase. The two centrosomes will give rise to the **mitotic spindle**, the apparatus that orchestrates the movement of chromosomes during mitosis. At the center of each animal cell, the centrosomes of animal cells are associated with a pair of rod-like objects, the **centrioles**, which are at right angles to each other. Centrioles help organize cell division. Centrioles are not present in the centrosomes of other eukaryotic species, such as plants and most fungi.

9.5 G_2 Phase (Second Gap)

In the **G_2 phase**, the cell replenishes its energy stores and synthesizes proteins necessary for chromosome manipulation. Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic phase. There may be additional cell growth during G_2. The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

9.6 The Mitotic Phase

The mitotic phase is a multistep process during which the duplicated chromosomes are aligned, separated, and move into two new, identical daughter cells. The first portion of the mitotic phase is called **karyokinesis**, or nuclear division. The second portion of the mitotic phase, called cytokinesis, is the physical separation of the cytoplasmic components into the two daughter cells.

Exercise 1. Visual connection questions.

- Describe the three stages of interphase
- Discuss the behavior of chromosomes during karyokinesis
- Explain how the cytoplasmic content is divided during cytokinesis
- Define the quiescent G_0 phase

Exercise 2. Visual Connection questions.

1.Which of the following is the correct order of events in mitosis?

a. Sister chromatids line up at the metaphase plate. The kinetochore becomes attached to the mitotic spindle. The nucleus reforms and the cell divides. Cohesin proteins break down and the sister chromatids separate.
b. The kinetochore becomes attached to the mitotic spindle. Cohesin proteins break down and the sister chromatids separate. Sister chromatids line up at the metaphase plate. The nucleus reforms and the cell divides.
c. The kinetochore becomes attached to the cohesin proteins. Sister chromatids line up at the metaphase plate. The kinetochore breaks down and the sister chromatids separate. The nucleus reforms and the cell divides.
d. The kinetochore becomes attached to the mitotic spindle. Sister chromatids line up at the metaphase plate. Cohesin proteins break down and the sister chromatids separate. The nucleus reforms and the cell divides.

2. Rb and other proteins that negatively regulate the cell cycle are sometimes called tumor suppressors. Why do you think the name tumor suppressor might be an appropriate for these proteins?

3. Human papillomavirus can cause cervical cancer. The virus encodes E6, a protein that binds p53. Based on this fact and what you know about p53, what effect do you think E6 binding has on p53 activity?

a. E6 activates p53
b. E6 inactivates p53
c. E6 mutates p53
d. E6 binding marks p53 for degradation

Exercise 3. Choose the correct answer.

1.A diploid cell has_______ the number of chromosomes as a haploid cell.

a. one-fourth
b. half
c. twice
d. four times

2.An organism's traits are determined by the specific combination of inherited _____.

a. cells.
b. genes.
c. proteins.
d. chromatids.

3.The first level of DNA organization in a eukaryotic cell is maintained by which molecule?

a. cohesin
b. condensin
c. chromatin
d. histone

4.Identical copies of chromatin held together by cohesin at the centromere are called _____.

a. histones.
b. nucleosomes.
c. chromatin.
d. sister chromatids.

5.Chromosomes are duplicated during what stage of the cell cycle?

a. G_1 phase
b. S phase
c. prophase
d. prometaphase

6.Which of the following events does not occur during some stages of interphase?

a. DNA duplication
b. organelle duplication
c. increase in cell size
d. separation of sister chromatids

7.The mitotic spindles arise from which cell structure?

a. centromere

b. centrosome
c. kinetochore
d. cleavage furrow

8.Attachment of the mitotic spindle fibers to the kinetochores is a characteristic of which stage of mitosis?

a. prophase
b. prometaphase
c. metaphase
d. anaphase

9.Unpacking of chromosomes and the formation of a new nuclear envelope is a characteristic of which stage of mitosis?

a. prometaphase
b. metaphase
c. anaphase
d. telophase

10.Separation of the sister chromatids is a characteristic of which stage of mitosis?

a. prometaphase
b. metaphase
c. anaphase
d. telophase

11.The chromosomes become visible under a light microscope during which stage of mitosis?

a. prophase
b. prometaphase
c. metaphase
d. anaphase

12.The fusing of Golgi vesicles at the metaphase plate of dividing plant cells forms what structure?

a. cell plate
b. actin ring
c. cleavage furrow
d. mitotic spindle

13.At which of the cell cycle checkpoints do external forces have the greatest influence?

a. G_1 checkpoint
b. G_2 checkpoint
c. M checkpoint
d. G_0 checkpoint

14.What is the main prerequisite for clearance at the G_2 checkpoint?

a. cell has reached a sufficient size

b. an adequate stockpile of nucleotides
c. accurate and complete DNA replication
d. proper attachment of mitotic spindle fibers to kinetochores

15.If the M checkpoint is not cleared, what stage of mitosis will be blocked?

a. prophase
b. prometaphase
c. metaphase
d. anaphase

16.Which protein is a positive regulator that phosphorylates other proteins when activated?

a. p53
b. retinoblastoma protein (Rb)
c. cyclin
d. cyclin-dependent kinase (Cdk)

17.Many of the negative regulator proteins of the cell cycle were discovered in what type of cells?

a. gametes
b. cells in G_0
c. cancer cells
d. stem cells

18.Which negative regulatory molecule can trigger cell suicide (apoptosis) if vital cell cycle events do not occur?

a. p53
b. p21
c. retinoblastoma protein (Rb)
d. cyclin-dependent kinase (Cdk)

19.____________ are changes to the order of nucleotides in a segment of DNA that codes for a protein.

a. Proto-oncogenes
b. Tumor suppressor genes
c. Gene mutations
d. Negative regulators

20.A gene that codes for a positive cell cycle regulator is called a(n) _____.

a. kinase inhibitor.
b. tumor suppressor gene.
c. proto-oncogene.
d. oncogene.

21.A mutated gene that codes for an altered version of Cdk that is active in the absence of cyclin is a(n) _____.

a. kinase inhibitor.
b. tumor suppressor gene.
c. proto-oncogene.
d. oncogene

22.Which molecule is a Cdk inhibitor that is controlled by p53?

a. cyclin
b. anti-kinase
c. Rb
d. p21

23.Which eukaryotic cell cycle event is missing in binary fission?

a. cell growth
b. DNA duplication
c. karyokinesis
d. cytokinesis

24.FtsZ proteins direct the formation of a _______ that will eventually form the new cell walls of the daughter cells.

a. contractile ring
b. cell plate
c. cytoskeleton
d. septum

Exercise 4. Critical thinking questions.

a. Compare and contrast a human somatic cell to a human gamete.
b. What is the relationship between a genome, chromosomes, and genes?
c. Eukaryotic chromosomes are thousands of times longer than a typical cell. Explain how chromosomes can fit inside a eukaryotic nucleus.
d. Briefly describe the events that occur in each phase of interphase.
e. Chemotherapy drugs such as vincristine and colchicine disrupt mitosis by binding to tubulin (the subunit of microtubules) and interfering with microtubule assembly and disassembly. Exactly what mitotic structure is targeted by these drugs and what effect would that have on cell division?
f. Describe the similarities and differences between the cytokinesis mechanisms found in animal cells versus those in plant cells.
g. List some reasons why a cell that has just completed cytokinesis might enter the G_0 phase instead of the G_1 phase.
h. What cell cycle events will be affected in a cell that produces mutated (non-functional) cohesin protein?
i. Describe the general conditions that must be met at each of the three main cell cycle checkpoints.
j. Explain the roles of the positive cell cycle regulators compared to the negative regulators.
k. What steps are necessary for Cdk to become fully active?
l. Rb is a negative regulator that blocks the cell cycle at the G_1 checkpoint until the cell achieves a requisite size. What molecular mechanism does Rb employ to halt the cell cycle?
m. Outline the steps that lead to a cell becoming cancerous.

n. Explain the difference between a proto-oncogene and a tumor suppressor gene.
o. List the regulatory mechanisms that might be lost in a cell producing faulty p53.
p. p53 can trigger apoptosis if certain cell cycle events fail. How does this regulatory outcome benefit a multicellular organism?
q. Name the common components of eukaryotic cell division and binary fission.
r. Describe how the duplicated bacterial chromosomes are distributed into new daughter cells without the direction of the mitotic spindle.

Unit 10. Genetics

Ability to reproduce	Здатність до розмноження
Offspring of any organism	Потомство будь-якого організму
Haploid cell	Гаплоїдна клітина
Mitotic cell division	Міотичний поділ клітин
Fertilization	Запліднення
Somatic cell	Соматична клітина
Spore	Спора
Life cycle	Життєвий цикл
Alternation of generations	Зміна поколінь
Algae	Водорості
Sexual reproduction	Статеве розмноження
Ploidy level	Рівень плоїдності
Evolutionary success	Еволюційний успіх

The ability to reproduce *in kind* is a basic characteristic of all living things. *In kind* means that the offspring of any organism closely resemble their parent or parents. Hippopotamuses give birth to hippopotamus calves, Joshua trees produce seeds from which Joshua tree seedlings emerge, and adult flamingos lay eggs that hatch into flamingo chicks. *In kind* does not generally mean *exactly the same*. Whereas many unicellular organisms and a few multicellular organisms can produce genetically identical clones of themselves through cell division, many single-celled organisms and most multicellular organisms reproduce regularly using another method. Sexual reproduction is the production by parents of two haploid cells and the fusion of two haploid cells to form a single, unique diploid cell. In most plants and animals, through tens of rounds of mitotic cell division, this diploid cell will develop into an adult organism. Haploid cells that are part of the sexual reproductive cycle are produced by a type of cell division called meiosis. Sexual reproduction, specifically meiosis and fertilization, introduces variation into offspring that may account for the evolutionary success of sexual reproduction. The vast majority of eukaryotic organisms, both multicellular and unicellular, can or must employ some form of meiosis and fertilization to reproduce.

Sexual reproduction requires **fertilization**, the union of two cells from two individual organisms. If those two cells each contain one set of chromosomes, then the resulting cell contains two sets of chromosomes. Haploid cells contain one set of chromosomes. Cells containing two sets of chromosomes are called diploid. The number of sets of chromosomes in a cell is called its ploidy level. If the reproductive cycle is to continue, then the diploid cell must somehow reduce its number of chromosome sets before fertilization can occur again, or there will be a continual doubling in the number of chromosome sets in every generation. So, in addition to fertilization, sexual reproduction includes a nuclear division that reduces the number of chromosome sets.

Most animals and plants are diploid, containing two sets of chromosomes. In each **somatic cell** of the organism (all cells of a multicellular organism except the gametes or reproductive cells), the nucleus contains two copies of each chromosome, called homologous chromosomes. Somatic cells are sometimes referred to as “body” cells. Homologous chromosomes are matched pairs containing the same genes in identical locations along their length. Diploid organisms inherit one copy of each homologous chromosome from each parent; all together, they are considered a full set of chromosomes. Haploid cells, containing a single copy of each homologous chromosome, are found only within structures that give rise to either gametes or spores. **Spores** are haploid cells that can produce a haploid organism or can fuse with another spore to form a diploid cell. All animals and most plants produce eggs and sperm, or gametes. Some plants and all fungi produce spores.

The nuclear division that forms haploid cells, which is called **meiosis**, is related to mitosis. As you have learned, mitosis is the part of a cell reproduction cycle that results in identical daughter nuclei that are also genetically identical to the original parent nucleus. In mitosis, both the parent and the daughter nuclei are at the same ploidy level—diploid for most plants and animals. Meiosis employs many of the same mechanisms as mitosis. However, the starting nucleus is always diploid and the nuclei that result at the end of a meiotic cell division are haploid. To achieve this reduction in chromosome number, meiosis consists of one round of chromosome duplication and two rounds of nuclear division. Because the events that occur during each of the division stages are analogous to the events of mitosis, the same stage names are assigned. However, because there are two rounds of division, the major process and the stages are designated with a “I” or a “II.” Thus, **meiosis I** is the first round of meiotic division and consists of prophase I, prometaphase I, and so on. **Meiosis II**, in which the second round of meiotic division takes place, includes prophase II, prometaphase II, and so on.

Meiosis I. Meiosis is preceded by an interphase consisting of the G_1, S, and G_2 phases, which are nearly identical to the phases preceding mitosis. The G_1 phase, which is also called the first gap phase, is the first phase of the interphase and is focused on cell growth. The S phase is the second phase of interphase, during which the DNA of the chromosomes is replicated. Finally, the G_2 phase, also called the second gap phase, is the third and final phase of interphase; in this phase, the cell undergoes the final preparations for meiosis.

During DNA duplication in the S phase, each chromosome is replicated to produce two identical copies, called sister chromatids, that are held together at the centromere by **cohesin** proteins. Cohesin holds the chromatids together until anaphase II. The centrosomes, which are the structures that organize the microtubules of the meiotic spindle, also replicate. This prepares the cell to enter prophase I, the first meiotic phase.

Meiosis II. In some species, cells enter a brief interphase, or **interkinesis**, before entering meiosis II. Interkinesis lacks an S phase, so chromosomes are not duplicated. The two cells produced in meiosis I go through the events of meiosis II in synchrony. During meiosis II, the sister chromatids within the two daughter cells separate, forming four new haploid gametes. The mechanics of meiosis II is similar to mitosis, except that each dividing cell has only one set of homologous chromosomes. Therefore, each cell has half the number of sister chromatids to separate out as a diploid cell undergoing mitosis.

Sexual reproduction. **Sexual reproduction** was an early evolutionary innovation after the appearance of eukaryotic cells. It appears to have been very successful because most eukaryotes are able to reproduce sexually, and in many animals, it is the only mode of reproduction. And yet, scientists recognize some real disadvantages to sexual reproduction. On the surface, creating offspring that are genetic clones of the parent appears to be a better system. If the parent organism is successfully occupying a habitat, offspring with the same traits would be similarly successful. There is also the obvious benefit to an organism that can produce offspring whenever circumstances are favorable by asexual budding, fragmentation, or asexual eggs. These methods of reproduction do not require another organism of the opposite sex. Indeed, some organisms that lead a solitary lifestyle have retained the ability to reproduce asexually. In addition, in asexual populations, every individual is capable of reproduction. In sexual populations, the males are not producing the offspring themselves, so in theory an asexual population could grow twice as fast.

However, multicellular organisms that exclusively depend on asexual reproduction are exceedingly rare. Why is sexuality (and meiosis) so common? This is one of the important unanswered questions in biology and has been the focus of much research beginning in the latter half of the twentieth century. There are several possible explanations, one of which is that the variation that sexual reproduction creates among offspring is very important to the survival and reproduction of the population. Thus, on average, a sexually reproducing population will leave more descendants than an otherwise similar asexually reproducing population. The only source of variation in asexual organisms is mutation. This is the ultimate source of variation in sexual organisms, but in addition, those different mutations are continually reshuffled from one generation to the next when different parents combine their unique genomes and the genes are mixed into different combinations by crossovers during prophase I and random assortment at metaphase I.

Evolution Connection

The Red Queen Hypothesis. It is not in dispute that sexual reproduction provides evolutionary advantages to organisms that employ this mechanism to produce offspring. But why, even in the face of fairly stable conditions, does sexual reproduction persist when it is more difficult and costly for individual organisms? Variation is the outcome of sexual reproduction, but why are ongoing variations necessary? Enter the Red Queen hypothesis, first proposed by Leigh Van Valen in 1973.[3] The concept was named in reference to the Red Queen's race in Lewis Carroll's book, *Through the Looking-Glass*.

All species co-evolve with other organisms; for example predators evolve with their prey, and parasites evolve with their hosts. Each tiny advantage gained by favorable variation gives a species an edge over close competitors, predators, parasites, or even prey. The only method that will allow a co-evolving species to maintain its own share of the resources is to also continually improve its fitness. As one species gains an advantage, this increases selection on the other species; they must also develop an advantage or they will be outcompeted. No single species progresses too far ahead because genetic variation among the progeny of sexual reproduction provides all species with a mechanism to improve rapidly. Species that cannot keep up become extinct. The Red Queen’s catchphrase was, “It takes all the running you can do to stay in the same place.” This is an apt description of co-evolution between competing species.

Life Cycles of Sexually Reproducing Organisms

Fertilization and meiosis alternate in sexual **life cycles**. What happens between these two events depends on the organism. The process of meiosis reduces the chromosome number by half. Fertilization, the joining of two haploid gametes, restores the diploid condition. There are three main categories of life cycles in multicellular organisms: **diploid-dominant**, in which the multicellular diploid stage is the most obvious life stage, such as with most animals including humans; **haploid-dominant**, in which the multicellular haploid stage is the most obvious life stage, such as with all fungi and some algae; and **alternation of generations**, in which the two stages are apparent to different degrees depending on the group, as with plants and some algae.

Exercise 1. Choose the correct answer.

1.Meiosis produces ________ daughter cells.

a. two haploid
b. two diploid
c. four haploid
d. four diploid

2.What structure is most important in forming the tetrads?

a. centromere
b. synaptonemal complex
c. chiasma
d. kinetochore

3.At which stage of meiosis are sister chromatids separated from each other?

a. prophase I
b. prophase II
c. anaphase I
d. anaphase II

4.At metaphase I, homologous chromosomes are connected only at what structures?

a. chiasmata
b. recombination nodules
c. microtubules
d. kinetochores

5.Which of the following is *not* true in regard to crossover?

a. Spindle microtubules guide the transfer of DNA across the synaptonemal complex.
b. Non-sister chromatids exchange genetic material.
c. Chiasmata are formed.
d. Recombination nodules mark the crossover point.

6.What phase of mitotic interphase is missing from meiotic interkinesis?

a. G_0 phase
b. G_1 phase
c. S phase
d. G_2 phase

7.The part of meiosis that is similar to mitosis is ________.

a. meiosis I
b. anaphase I
c. meiosis II
d. interkinesis

8.If a muscle cell of a typical organism has 32 chromosomes, how many chromosomes will be in a gamete of that same organism?

a. 8
b. 16
c. 32
d. 64

9.What is a likely evolutionary advantage of sexual reproduction over asexual reproduction?

a. Sexual reproduction involves fewer steps.
b. There is a lower chance of using up the resources in a given environment.
c. Sexual reproduction results in variation in the offspring.
d. Sexual reproduction is more cost-effective

9.Which type of life cycle has both a haploid and diploid multicellular stage?

a. asexual
b. diploid-dominant
c. haploid-dominant
d. alternation of generations

10.Fungi typically display which type of life cycle?

a. diploid-dominant
b. haploid-dominant
c. alternation of generations
d. asexual

11.A diploid, multicellular life-cycle stage that gives rise to haploid cells by meiosis is called a ________.

a. sporophyte
b. gametophyte
c. spore
d. gamete

Exercise 2. Critical thinking Questions.

a. Describe the process that results in the formation of a tetrad.
b. Explain how the random alignment of homologous chromosomes during metaphase I contributes to the variation in gametes produced by meiosis.
c. What is the function of the fused kinetochore found on sister chromatids in prometaphase I?
d. In a comparison of the stages of meiosis to the stages of mitosis, which stages are unique to meiosis and which stages have the same events in both meiosis and mitosis?
e. List and briefly describe the three processes that lead to variation in offspring with the same parents.
f. Compare the three main types of life cycles in multicellular organisms and give an example of an organism that employs each.

Unit 11. VIRUSES

Discovery and detection	Відкриття і виявлення
Virion	Віріон
Replication method	Метод тиражування
Fungi	Гриби
Diversity	Різноманіття
Host cell	Клітина-господар
Viral morphology	Морфологія вірусу
Acellular	Безклітинний
To replicate	Тиражувати
Archaea	Архей
Outer protein	Зовнішній білок
Emerging field	Нова сфера
Genetic material	Генетичний матеріал
Viral disease	Вірусне захворювання

No one knows exactly when viruses emerged or from where they came, since viruses do not leave historical footprints such as fossils. Modern viruses are thought to be a mosaic of bits and pieces of nucleic acids picked up from various sources along their respective evolutionary paths. Viruses are acellular, parasitic entities that are not classified within any kingdom. Unlike most living organisms, viruses are not cells and cannot divide. Instead, they infect a host cell and use the host's replication processes to produce identical progeny virus particles. Viruses infect organisms as diverse as bacteria, plants, and animals. They exist in a netherworld between a living organism and a nonliving entity. Living things grow, metabolize, and reproduce. Viruses replicate, but to do so, they are entirely dependent on their host cells. They do not metabolize or grow, but are assembled in their mature form.

Viruses are diverse entities. They vary in their structure, their replication methods, and in their target hosts. Nearly all forms of life—from bacteria and archaea to eukaryotes such as plants, animals, and fungi—have viruses that infect them. While most biological diversity can be understood through evolutionary history, such as how species have adapted to conditions and environments, much about virus origins and evolution remains unknown.

11.1 Discovery and Detection

Viruses were first discovered after the development of a porcelain filter, called the Chamberland-Pasteur filter, which could remove all bacteria visible in the microscope from any liquid sample. In 1886, Adolph Meyer demonstrated that a disease of tobacco plants, tobacco mosaic disease, could be transferred from a diseased plant to a healthy one via liquid plant extracts. In 1892, Dmitri Ivanowski showed that this disease could be transmitted in this way even after the Chamberland-Pasteur filter had removed all viable bacteria from the extract. Still, it was many years before it was proven that these "filterable" infectious agents were not simply very small bacteria but were a new type of very small, disease-causing particle.

Virions, single virus particles, are very small, about 20–250 nanometers in diameter. These individual virus particles are the infectious form of a virus outside the host cell. Unlike bacteria (which are about 100-times larger), we cannot see viruses with a light microscope, with the exception of some large virions of the poxvirus family. It was not until the development of the electron microscope in the late 1930s that scientists got their first good view of the structure of the tobacco mosaic virus (TMV) and other viruses. The surface structure of virions can be observed by both scanning and transmission electron microscopy, whereas the internal structures of the virus can only be observed in images from a transmission electron microscope. The use of these technologies has allowed for the discovery of many viruses of all types of living organisms. They were initially grouped by shared morphology. Later, groups of viruses were classified by the type of nucleic acid they contained, DNA or RNA, and whether their nucleic acid was single- or double-stranded. More recently, molecular analysis of viral replicative cycles has further refined their classification.

11.2 Evolution of Viruses

Although biologists have accumulated a significant amount of knowledge about how present-day viruses evolve, much less is known about how viruses originated in the first place. When exploring the evolutionary history of most organisms, scientists can look at fossil records and similar historic evidence. However, viruses do not fossilize, so researchers must conjecture by investigating how today's viruses evolve and by using biochemical and genetic information to create speculative virus histories.

While most findings agree that viruses don't have a single common ancestor, scholars have yet to find a single hypothesis about virus origins that is fully accepted in the field. One such hypothesis, called devolution or the regressive hypothesis, proposes to explain the origin of viruses by suggesting that viruses evolved from free-living cells. However, many components of how this process might have occurred are a mystery. A second hypothesis (called escapist or the progressive hypothesis) accounts for viruses having either an RNA or a DNA genome and suggests that viruses originated from RNA and DNA molecules that escaped from a host cell. A third hypothesis posits a system of self-replication similar to that of other self-replicating molecules, likely evolving alongside the cells they rely on as hosts; studies of some plant pathogens support this hypothesis.

As technology advances, scientists may develop and refine further hypotheses to explain the origin of viruses. The emerging field called virus molecular systematics attempts to do just that through comparisons of sequenced genetic material. These researchers hope to one day better understand the origin of viruses, a discovery that could lead to advances in the treatments for the ailments they produce.

11.3 Viral Morphology

Viruses are **acellular**, meaning they are biological entities that do not have a cellular structure. They therefore lack most of the components of cells, such as organelles, ribosomes, and the plasma membrane. A virion consists of a nucleic acid core, an outer protein coating or capsid, and sometimes an outer **envelope** made of protein and phospholipid membranes derived from the host cell. Viruses may also contain additional proteins, such as enzymes. The most obvious difference between members of viral families is their morphology, which is quite diverse. An interesting feature of viral complexity is that the complexity of the host does not correlate with the complexity of the virion. Some of the most complex virion structures are observed in bacteriophages, viruses that infect the simplest living organisms, bacteria.

Exercise 1. Visual connection questions.

1. Which of the following statements about virus structure is true?

a. All viruses are encased in a viral membrane.
b. The capsomere is made up of small protein subunits called capsids.
c. DNA is the genetic material in all viruses.
d. Glycoproteins help the virus attach to the host cell.

2. Influenza virus is packaged in a viral envelope that fuses with the plasma membrane. This way, the virus can exit the host cell without killing it. What advantage does the virus gain by keeping the host cell alive?
3. Which of the following statements is false?

a. In the lytic cycle, new phage are produced and released into the environment.
b. In the lysogenic cycle, phage DNA is incorporated into the host genome.
c. An environmental stressor can cause the phage to initiate the lysogenic cycle.
d. Cell lysis only occurs in the lytic cycle.

Exercise 2. Choose the correct answer.

1.Which statement is true?

a. A virion contains DNA and RNA.
b. Viruses are acellular.
c. Viruses replicate outside of the cell.
d. Most viruses are easily visualized with a light microscope.

2.The viral ________ plays a role in attaching a virion to the host cell.

a. core
b. capsid
c. envelope
d. both b and c

3.Viruses_______.

a. all have a round shape
b. cannot have a long shape
c. do not maintain any shape
d. vary in shape

4.Which statement is *not* true of viral replication?

a. A lysogenic cycle kills the host cell.
b. There are six basic steps in the viral replication cycle.
c. Viral replication does not affect host cell function.
d. Newly released virions can infect adjacent cells.

5.Which statement is true of viral replication?

a. In the process of apoptosis, the cell survives.
b. During attachment, the virus attaches at specific sites on the cell surface.
c. The viral capsid helps the host cell produce more copies of the viral genome.

d. mRNA works outside of the host cell to produce enzymes and proteins.

5.Which statement is true of reverse transcriptase?

a. It is a nucleic acid.
b. It infects cells.
c. It transcribes RNA to make DNA.
d. It is a lipid.

6.Oncogenic virus cores can be_______.

a. RNA
b. DNA
c. neither RNA nor DNA
d. either RNA or DNA

7.Which is true of DNA viruses?

a. They use the host cell's machinery to produce new copies of their genome.
b. They all have envelopes.
c. They are the only kind of viruses that can cause cancer.
d. They are not important plant pathogens.

8.A bacteriophage can infect ________.

a. the lungs
b. viruses
c. prions
d. bacteria

9.Which of the following is NOT used to treat active viral disease?

a. vaccines
b. antiviral drugs
c. antibiotics
d. phage therapy

10.Vaccines_______.

a. are similar to viroids
b. are only needed once
c. kill viruses
d. stimulate an immune response

11.Which of the following is not associated with prions?

a. replicating shapes
b. mad cow disease
c. DNA
d. toxic proteins

12.Which statement is true of viroids?

a. They are single-stranded RNA particles.
b. They reproduce only outside of the cell.
c. They produce proteins.
d. They affect both plants and animals.

Exercise 3. Critical thinking questions.

a. The first electron micrograph of a virus (tobacco mosaic virus) was produced in 1939. Before that time, how did scientists know that viruses existed if they could not see them? (Hint: Early scientists called viruses “filterable agents.”)
b. Why can’t dogs catch the measles?
c. One of the first and most important targets for drugs to fight infection with HIV (a retrovirus) is the reverse transcriptase enzyme. Why?
d. In this section, you were introduced to different types of viruses and viral diseases. Briefly discuss the most interesting or surprising thing you learned about viruses.
e. Although plant viruses cannot infect humans, what are some of the ways in which they affect humans?
f. Why is immunization after being bitten by a rabid animal so effective and why aren’t people vaccinated for rabies like dogs and cats are?
g. Prions are responsible for variant Creutzfeldt-Jakob Disease, which has resulted in over 100 human deaths in Great Britain during the last 10 years. How do humans obtain this disease?
h. How are viroids like viruses?

Unit 12. Diversity of Prokaryotes

Diversity of prokaryotes	Різноманіття прокаріотів
Ubiquitous	Всюдисущий
First inhabitant	Перший житель
Inhospitable environment	Несприятливе навколишнє середовище
Multicellular life	Багатоклітинне життя
Mutagenic radiation	Мутогенне випромінювання
Fossilized microbial mat	Викопний мікробний мат
Hydrothermal vent	Гідротермальне джерело
Stromatolite	Строматоліт
Sedimentary structure	Осадова структура
Radioresistant organism	Радіостійкий організм
Layered rocks	Пластова порода
Carbonate	Карбонат, вуглецева сіль
Silicate	Силікат
Extreme environments (pl.)	Екстримальні умови

Prokaryotes are ubiquitous. They cover every imaginable surface where there is sufficient moisture, and they live on and inside of other living things. In the typical human body, prokaryotic cells outnumber human body cells by about ten to one. They comprise the majority of living things in all ecosystems. Some prokaryotes thrive in environments that are inhospitable for most living things. Prokaryotes recycle **nutrients**—essential substances (such as carbon and nitrogen)—and they drive the evolution of new ecosystems, some of which are natural and others man-made. Prokaryotes have been on Earth since long before multicellular life appeared.

12.1 Prokaryotes, the First Inhabitants of Earth

When and where did life begin? What were the conditions on Earth when life began? Prokaryotes were the first forms of life on Earth, and they existed for billions of years before plants and animals appeared. The Earth and its moon are thought to be about 4.54 billion years old. This estimate is based on evidence from radiometric dating of meteorite material together with other substrate material from Earth and the moon. Early Earth had a very different atmosphere (contained less molecular oxygen) than it does today and was subjected to strong radiation; thus, the first organisms would have flourished where they were more protected, such as in ocean depths or beneath the surface of the Earth. At this time too, strong volcanic activity was common on Earth, so it is likely that these first organisms—the first prokaryotes—were adapted to very high temperatures. Early Earth was prone to geological upheaval and volcanic eruption, and was subject to bombardment by mutagenic radiation from the sun. The first organisms were prokaryotes that could withstand these harsh conditions.

12.2 Microbial Mats

Microbial mats or large biofilms may represent the earliest forms of life on Earth; there is fossil evidence of their presence starting about 3.5 billion years ago. A **microbial mat** is a multi-layered sheet of prokaryotes that includes mostly bacteria, but also archaea. Microbial mats are a few centimeters thick, and they typically grow where different types of materials interface, mostly on moist surfaces. The various types of prokaryotes that comprise them carry out different metabolic pathways, and that is the reason for their various colors. Prokaryotes in a microbial mat are held together by a glue-like sticky substance that they secrete called extracellular matrix.

The first microbial mats likely obtained their energy from chemicals found near hydrothermal vents. A **hydrothermal vent** is a breakage or fissure in the Earth's surface that releases geothermally heated water. With the evolution of photosynthesis about 3 billion years ago, some prokaryotes in microbial mats came to use a more widely available energy source—sunlight—whereas others were still dependent on chemicals from hydrothermal vents for energy and food.

12.3 Stromatolites

Fossilized microbial mats represent the earliest record of life on Earth. A **stromatolite** is a sedimentary structure formed when minerals are precipitated out of water by prokaryotes in a microbial mat. Stromatolites form layered rocks made of carbonate or silicate. Although most stromatolites are artifacts from the past, there are places on Earth where stromatolites are still forming. For example, growing stromatolites have been found in the Anza-Borrego Desert State Park in San Diego County, California.

12.4 The Ancient Atmosphere

Evidence indicates that during the first two billion years of Earth's existence, the atmosphere was **anoxic**, meaning that there was no molecular oxygen. Therefore, only those organisms that can grow without oxygen—**anaerobic** organisms—were able to live. Autotrophic organisms that convert solar energy into chemical energy are called **phototrophs**, and they appeared within one billion years of the formation of Earth. Then, **cyanobacteria**, also known as blue-green algae, evolved from these simple phototrophs one billion years later. Cyanobacteria began the oxygenation of the atmosphere. Increased atmospheric oxygen allowed the development of more efficient O_2-utilizing catabolic pathways. It also opened up the land to increased colonization, because some O_2 is converted into O_3 (ozone) and ozone effectively absorbs the ultraviolet light that would otherwise cause lethal mutations in DNA. Ultimately, the increase in O_2 concentrations allowed the evolution of other life forms.

12.5 Microbes Are Adaptable: Life in Moderate and Extreme Environments

Some organisms have developed strategies that allow them to survive harsh conditions. Prokaryotes thrive in a vast array of environments: Some grow in conditions that would seem very normal to us, whereas others are able to thrive and grow under conditions that would kill a plant or animal. Almost all prokaryotes have a cell wall, a protective structure that allows them to survive in both hyper- and hypo-osmotic conditions. Some soil bacteria are able to form endospores that resist heat and drought, thereby allowing the organism to survive until favorable conditions recur. These adaptations, along with others, allow bacteria to be the most abundant life form in all terrestrial and aquatic ecosystems.

Other bacteria and archaea are adapted to grow under extreme conditions and are called **extremophiles**, meaning “lovers of extremes.” Extremophiles have been found in all kinds of environments: the depth of the oceans, hot springs, the Artic and the Antarctic, in very dry places, deep inside Earth, in harsh chemical environments, and in high radiation environments, just to mention a few. These organisms give us a better understanding of prokaryotic diversity and open up the possibility of finding new prokaryotic species that may lead to the discovery of new therapeutic drugs or have industrial applications. Because they have specialized adaptations that allow them to live in extreme conditions, many extremophiles cannot survive in moderate environments. There are many different groups of extremophiles: They are identified based on the conditions in which they grow best, and several habitats are extreme in multiple ways. For example, a soda lake is both salty and alkaline, so organisms that live in a soda lake must be both alkaliphiles and halophiles. Other extremophiles, like **radioresistant** organisms, do not prefer an extreme environment (in this case, one with high levels of radiation), but have adapted to survive in it

Not all prokaryotes are pathogenic. On the contrary, pathogens represent only a very small percentage of the diversity of the microbial world. In fact, our life would not be possible without prokaryotes. Just think about the role of prokaryotes in biogeochemical cycles.

Exercise 1. Visual Connection Questions.

1.Compared to free-floating bacteria, bacteria in biofilms often show increased resistance to antibiotics and detergents. Why do you think this might be the case?

2. Which of the following statements is true?

a. Gram-positive bacteria have a single cell wall anchored to the cell membrane by lipoteichoic acid.
b. Porins allow entry of substances into both Gram-positive and Gram-negative bacteria.
c. The cell wall of Gram-negative bacteria is thick, and the cell wall of Gram-positive bacteria is thin.
d. Gram-negative bacteria have a cell wall made of peptidoglycan, whereas Gram-positive bacteria have a cell wall made of lipoteichoic acid.

Exercise 2. Choose the correct answer.

1.The first forms of life on Earth were thought to be_________.

a. single-celled plants
b. prokaryotes
c. insects
d. large animals such as dinosaurs

2.Microbial mats __________.

a. are the earliest forms of life on Earth
b. obtained their energy and food from hydrothermal vents
c. are multi-layered sheet of prokaryotes including mostly bacteria but also archaea
d. all of the above

3.The first organisms that oxygenated the atmosphere were

a. cyanobacteria
b. phototrophic organisms
c. anaerobic organisms
d. all of the above

4.Halophiles are organisms that require________.

a. a salt concentration of at least 0.2 M
b. high sugar concentration
c. the addition of halogens
d. all of the above

5.The presence of a membrane-enclosed nucleus is a characteristic of ________.

a. prokaryotic cells
b. eukaryotic cells
c. all cells
d. viruses

6.Which of the following consist of prokaryotic cells?

a. bacteria and fungi
b. archaea and fungi
c. protists and animals
d. bacteria and archaea

7.The cell wall is ________.

a. interior to the cell membrane
b. exterior to the cell membrane
c. a part of the cell membrane
d. interior or exterior, depending on the particular cell

8.Organisms most likely to be found in extreme environments are ________.

a. fungi
b. bacteria
c. viruses
d. archaea

9.Prokaryotes stain as Gram-positive or Gram-negative because of differences in the cell _____.

a. wall
b. cytoplasm
c. nucleus
d. chromosome

10.Pseudopeptidoglycan is a characteristic of the walls of ________.

a. eukaryotic cells
b. bacterial prokaryotic cells
c. archaean prokaryotic cells
d. bacterial and archaean prokaryotic cells

11.The lipopolysaccharide layer (LPS) is a characteristic of the wall of ________.

a. archaean cells
b. Gram-negative bacteria
c. bacterial prokaryotic cells
d. eukaryotic cells

12.Which of the following elements is *not* a micronutrient?

a. boron
b. calcium
c. chromium
d. manganese

13.Prokaryotes that obtain their energy from chemical compounds are called _____.

a. phototrophs
b. auxotrophs
c. chemotrophs
d. lithotrophs

14.Ammonification is the process by which _____.

a. ammonia is released during the decomposition of nitrogen-containing organic compounds
b. ammonium is converted to nitrite and nitrate in soils
c. nitrate from soil is transformed to gaseous nitrogen compounds such as NO, N_2O, and N_2
d. gaseous nitrogen is fixed to yield ammonia

15.Plants use carbon dioxide from the air and are therefore called _____.

a. consumers
b. producers

c. decomposer
d. carbon fixers

16. A disease that is constantly present in a population is called _____.

a. pandemic
b. epidemic
c. endemic
d. re-emerging

17. Which of the statements about biofilms is incorrect?

a. Biofilms are considered responsible for diseases such as cystic fibrosis.
b. Biofilms produce dental plaque, and colonize catheters and prostheses.
c. Biofilms colonize open wounds and burned tissue.
d. All statements are incorrect.

18. Which of these statements is true?

a. An antibiotic is any substance produced by a organism that is antagonistic to the growth of prokaryotes.
b. An antibiotic is any substance produced by a prokaryote that is antagonistic to the growth of other viruses.
c. An antibiotic is any substance produced by a prokaryote that is antagonistic to the growth of eukaryotic cells.
d. An antibiotic is any substance produced by a prokaryote that prevents growth of the same prokaryote.

19. Which of these occurs through symbiotic nitrogen fixation?

a. The plant benefits from using an endless source of nitrogen.
b. The soil benefits from being naturally fertilized.
c. Bacteria benefit from using photosynthates from the plant.
d. All of the above occur.

20. Synthetic compounds found in an organism but not normally produced or expected to be present in that organism are called _____.

a. pesticides
b. bioremediators
c. recalcitrant compounds
d. xenobiotics

21. Bioremediation includes _____.

a. the use of prokaryotes that can fix nitrogen
b. the use of prokaryotes to clean up pollutants
c. the use of prokaryotes as natural fertilizers
d. All of the above

Exercise 3. Critical thinking questions.

a. Describe briefly how you would detect the presence of a non-culturable prokaryote in an environmental sample.
b. Why do scientists believe that the first organisms on Earth were extremophiles?
c. Mention three differences between bacteria and archaea.
d. Explain the statement that both types, bacteria and archaea, have the same basic structures, but built from different chemical components.
e. Think about the conditions (temperature, light, pressure, and organic and inorganic materials) that you may find in a deep-sea hydrothermal vent. What type of prokaryotes, in terms of their metabolic needs (autotrophs, phototrophs, chemotrophs, etc.), would you expect to find there?
f. Explain the reason why the imprudent and excessive use of antibiotics has resulted in a major global problem.
g. Researchers have discovered that washing spinach with water several times does not prevent foodborne diseases due to *E. coli*. How can you explain this fact?
h. Your friend believes that prokaryotes are always detrimental and pathogenic. How would you explain to them that they are wrong?

Unit 13. Fungi

Fungus, fungi *pl.*	Грибок
Reproductive structure	Репродуктивна структура
Heterotrophic	Гетерофобний
Starch	Крохмаль
Complex organic compound	Складна органічна сполука
Dikaryotic ascus	Дикаріотичний аскус
Root	Корінь
Vascular system	Судинна система
Fungal infection	Грибкова інфекція
Fungal filament	Грибна нитка
Homothallic mycelium	Гомоталічний міцелій
Spore	Спора
mutualistic associations	

The word *fungus* comes from the Latin word for mushrooms. Indeed, the familiar mushroom is a reproductive structure used by many types of fungi. However, there are also many fungi species that don't produce mushrooms at all. Being eukaryotes, a typical fungal cell contains a true nucleus and many membrane-bound organelles. The kingdom Fungi includes an enormous variety of living organisms collectively referred to as Eucomycota, or true Fungi. While scientists have identified about 100,000 species of fungi, this is only a fraction of the 1.5 million species of fungus likely present on Earth. Edible mushrooms, yeasts, black mold, and the producer of the antibiotic penicillin, *Penicillium notatum*, are all members of the kingdom Fungi, which belongs to the domain Eukarya.

Fungi, once considered plant-like organisms, are more closely related to animals than plants. Fungi are not capable of photosynthesis: they are heterotrophic because they use complex organic compounds as sources of energy and carbon. Some fungal organisms multiply only asexually, whereas others undergo both asexual reproduction and sexual reproduction with alternation of generations. Most fungi produce a large number of **spores**, which are haploid cells that can undergo mitosis to form multicellular, haploid individuals. Like bacteria, fungi play an essential role in ecosystems because they are decomposers and participate in the cycling of nutrients by breaking down organic materials to simple molecules.

Fungi often interact with other organisms, forming beneficial or mutualistic associations. For example most terrestrial plants form symbiotic relationships with fungi. The roots of the plant connect with the underground parts of the fungus forming **mycorrhizae**. Through mycorrhizae, the fungus and plant exchange nutrients and water, greatly aiding the survival of both species Alternatively, lichens are an association between a fungus and its photosynthetic partner (usually an alga). Fungi also cause serious infections in plants and animals. For example, Dutch elm disease, which is caused by the fungus *Ophiostoma ulmi*, is a particularly devastating type of fungal infestation that destroys many native species of elm (*Ulmus* sp.) by infecting the tree's vascular system. The elm bark beetle acts as a vector, transmitting the disease from tree to tree. Accidentally introduced in the 1900s, the fungus decimated elm trees across the continent. Many European and Asiatic elms are less susceptible to Dutch elm disease than American elms.

In humans, fungal infections are generally considered challenging to treat. Unlike bacteria, fungi do not respond to traditional antibiotic therapy, since they are eukaryotes. Fungal infections may prove deadly for individuals with compromised immune systems.

Fungi have many commercial applications. The food industry uses yeasts in baking, brewing, and cheese and wine making. Many industrial compounds are byproducts of fungal fermentation. Fungi are the source of many commercial enzymes and antibiotics.

Exercise 1. Visual connection questions.

1.Which of the following statements is true?

a. A dikaryotic ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
b. A diploid ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
c. A haploid zygote that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
d. A dikaryotic ascus that forms in the ascocarp undergoes plasmogamy, meiosis, and mitosis to form eight ascospores.

2.Which of the following statements is true?

a. A basidium is the fruiting body of a mushroom-producing fungus, and it forms four basidiocarps.
b. The result of the plasmogamy step is four basidiospores.
c. Karyogamy results directly in the formation of mycelia.
d. A basidiocarp is the fruiting body of a mushroom-producing fungus.

3.If symbiotic fungi are absent from the soil, what impact do you think this would have on plant growth?

Exercise 2. Choose the correct answer.

1.Which polysaccharide is usually found in the cell wall of fungi?

a. starch

b. glycogen
c. chitin
d. cellulose

2.Which of these organelles is not found in a fungal cell?

a. chloroplast
b. nucleus
c. mitochondrion
d. Golgi apparatus

3.The wall dividing individual cells in a fungal filament is called a

a. thallus
b. hypha
c. mycelium
d. septum

4.During sexual reproduction, a homothallic mycelium contains

a. all septated hyphae
b. all haploid nuclei
c. both mating types
d. none of the above

5.The most primitive phylum of fungi is the ________.

a. Chytridiomycota
b. Zygomycota
c. Glomeromycota
d. Ascomycota

6.Members of which phylum produce a club-shaped structure that contains spores?

a. Chytridiomycota
b. Basidiomycota
c. Glomeromycota
d. Ascomycota

7.Members of which phylum establish a successful symbiotic relationship with the roots of trees?

a. Ascomycota
b. Deuteromycota
c. Basidiomycota
d. Glomeromycota

8.The fungi that do not reproduce sexually use to be classified as ________.

a. Ascomycota
b. Deuteromycota
c. Basidiomycota

d. Glomeromycota

9.What term describes the close association of a fungus with the root of a tree?

a. a rhizoid
b. a lichen
c. a mycorrhiza
d. an endophyte

10.Why are fungi important decomposers?

a. They produce many spores.
b. They can grow in many different environments.
c. They produce mycelia.
d. They recycle carbon and inorganic minerals by the process of decomposition.

11.A fungus that climbs up a tree reaching higher elevation to release its spores in the wind and does not receive any nutrients from the tree or contribute to the tree's welfare is described as a ________.

a. commensal
b. mutualist
c. parasite
d. pathogen

12.A fungal infection that affects nails and skin is classified as ________.

a. systemic mycosis
b. mycetismus
c. superficial mycosis
d. mycotoxicosis

13.Yeast is a facultative anaerobe. This means that alcohol fermentation takes place only if:

a. the temperature is close to 37°C
b. the atmosphere does not contain oxygen
c. sugar is provided to the cells
d. light is provided to the cells

14.The advantage of yeast cells over bacterial cells to express human proteins is that:

a. yeast cells grow faster
b. yeast cells are easier to manipulate genetically
c. yeast cells are eukaryotic and modify proteins similarly to human cells
d. yeast cells are easily lysed to purify the proteins

Exercise 3. Critical thinking questions.

a. What are the evolutionary advantages for an organism to reproduce both asexually and sexually?

b. Compare plants, animals, and fungi, considering these components: cell wall, chloroplasts, plasma membrane, food source, and polysaccharide storage. Be sure to indicate fungi’s similarities and differences to plants and animals.
c. What is the advantage for a basidiomycete to produce a showy and fleshy fruiting body?
d. For each of the four groups of perfect fungi (Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota), compare the body structure and features, and provide an example.
e. Why does protection from light actually benefit the photosynthetic partner in lichens?
f. Why can superficial mycoses in humans lead to bacterial infections?
g. Historically, artisanal breads were produced by capturing wild yeasts from the air. Prior to the development of modern yeast strains, the production of artisanal breads was long and laborious because many batches of dough ended up being discarded. Can you explain this fact?

Unit 14. Animal Diversity

Complex tissue	Складна тканина
Heterotroph	Гетеротроф
Multicellular organism	Багатоклітинний організм
Developmental cue	Проблема розвитку
Radial symmetry	Радіальна симетрія
Bilateral symmetry	Двостороння симетрія
Bilaterian	Двосторонній
Life cycle	Життєвий цикл
Kingdom animalia	Царство тварин
Invertebrates	Безхребетні
Vertebrates	Хребетні
Endoderm	Ендодерм
Mesoderm	Мезодерм
Ectoderm	Ектодерм

Even though members of the animal kingdom are incredibly diverse, most animals share certain features that distinguish them from organisms in other kingdoms. All animals are eukaryotic, multicellular organisms, and almost all animals have a complex tissue structure with differentiated and specialized tissues. Most animals are motile, at least during certain life stages. All animals require a source of food and are therefore heterotrophic, ingesting other living or dead organisms; this feature distinguishes them from autotrophic organisms, such as most plants, which synthesize their own nutrients through photosynthesis. As heterotrophs, animals may be carnivores, herbivores, omnivores, or parasites. Most animals reproduce sexually, and the offspring pass through a series of developmental stages that establish a determined and fixed body plan. The **body plan** refers to the morphology of an animal, determined by developmental cues.

As multicellular organisms, animals differ from plants and fungi because their cells don’t have cell walls, their cells may be embedded in an extracellular matrix (such as bone, skin, or connective tissue), and their cells have unique structures for intercellular communication (such as gap junctions). In addition, animals possess unique tissues, absent in fungi and plants, which allow coordination (nerve tissue) of motility (muscle tissue). Animals are also characterized by specialized connective tissues that provide structural support for cells and organs. This connective tissue constitutes the extracellular surroundings of cells and is made up of organic and inorganic materials. In vertebrates, bone tissue is a type of connective tissue that supports the entire body structure. The complex bodies and activities of vertebrates demand such supportive tissues. Epithelial tissues cover, line, protect, and secrete. Epithelial tissues include the epidermis of the integument, the lining of the digestive tract and trachea, and make up the ducts of the liver and glands of advanced animals.

The animal kingdom is divided into Parazoa (sponges) and Eumetazoa (all other animals). As very simple animals, the organisms in group Parazoa ("beside animal") do not contain true specialized tissues; although they do possess specialized cells that perform different functions, those cells are not organized into tissues. These organisms are considered animals since they lack the ability to make their own food. Animals with true tissues are in the group Eumetazoa ("true animals"). When we think of animals, we usually think of Eumetazoans, since most animals fall into this category.

The different types of tissues in true animals are responsible for carrying out specific functions for the organism. This differentiation and specialization of tissues is part of what allows for such incredible animal diversity. For example, the evolution of nerve tissues and muscle tissues has resulted in animals' unique ability to rapidly sense and respond to changes in their environment. This allows animals to survive in environments where they must compete with other species to meet their nutritional demands.

Exercise 1. Visual connection questions.

1.If a *Hox 13* gene in a mouse was replaced with a *Hox 1* gene, how might this alter animal development?

2.Which of the following statements is false?

a. Eumetazoans have specialized tissues and parazoans don't.
b. Lophotrochozoa and Ecdysozoa are both Bilataria.
c. Acoela and Cnidaria both possess radial symmetry.
d. Arthropods are more closely related to nematodes than they are to annelids.

3.Which of the following statements about diploblasts and triploblasts is false?

a. Animals that display radial symmetry are diploblasts.
b. Animals that display bilateral symmetry are triploblasts.
c. The endoderm gives rise to the lining of the digestive tract and the respiratory tract.
d. The mesoderm gives rise to the central nervous system.

Exercise 2. Choose the correct answer.

1.Which of the following is not a feature common to *most* animals?

a. development into a fixed body plan

b. asexual reproduction
c. specialized tissues
d. heterotrophic nutrient sourcing

2.During embryonic development, unique cell layers develop and distinguish during a stage called ________.

a. the blastula stage
b. the germ layer stage
c. the gastrula stage
d. the organogenesis stage

3.Which of the following phenotypes would most likely be the result of a *Hox* gene mutation?

a. abnormal body length or height
b. two different eye colors
c. the contraction of a genetic illness
d. two fewer appendages than normal

4.Which of the following organism is most likely to be a diploblast?

a. sea star
b. shrimp
c. jellyfish
d. insect

5.Which of the following is not possible?

a. radially symmetrical diploblast
b. diploblastic eucoelomate
c. protostomic coelomate
d. bilaterally symmetrical deuterostome

6.An animal whose development is marked by radial cleavage and enterocoely is ________.

a. a deuterostome
b. an annelid or mollusk
c. either an acoelomate or eucoelomate
d. none of the above

7.Consulting the modern phylogenetic tree of animals, which of the following would not constitute a clade?

a. deuterostomes
b. lophotrochozoans
c. Parazoa
d. Bilateria

8.Which of the following is thought to be the most closely related to the common animal ancestor?

a. fungal cells

b. protist cells
c. plant cells
d. bacterial cells

Exercise 3. Critical thinking questions.

a. Why might the evolution of specialized tissues be important for animal function and complexity?
b. Describe and give examples of how humans display all of the features common to the animal kingdom.
c. How have *Hox* genes contributed to the diversity of animal body plans?
d. Using the following terms, explain what classifications and groups humans fall into, from the most general to the most specific: symmetry, germ layers, coelom, cleavage, embryological development.
e. Explain some of the advantages brought about through the evolution of bilateral symmetry and coelom formation.

Unit 15. Animal Structure and Functions

Distinct body plan	Чітка будова тіла
Asymmetrical animals	Асиметричні тварини
Radial symmetry	Радіальна симетрія
Fusiform shape	Веретеноподібна форма
Exoskeleton	Екзоскелет
Aquaticc animals	Водні тварини
Land-based animals	Наземні тварини
Apodeme	Аподема
Insect	Комаха
Crustaceans	Ракоподібні
Ventral	Вентральний
Anterior	Передній
Posterior	Задній

Animals vary in form and function. From a sponge to a worm to a goat, an organism has a distinct body plan that limits its size and shape. Animals' bodies are also designed to interact with their environments, whether in the deep sea, a rainforest canopy, or the desert. Therefore, a large amount of information about the structure of an organism's body (anatomy) and the function of its cells, tissues and organs (physiology) can be learned by studying that organism's environment.

Animal body plans follow set patterns related to symmetry. They are asymmetrical, radial, or bilateral in form as illustrated in. **Asymmetrical** animals are animals with no pattern or symmetry; an example of an asymmetrical animal is a sponge. Radial symmetry, as illustrated in, describes when an animal has an up-and-down orientation: any plane cut along its longitudinal axis through the organism produces equal halves, but not a definite right or left side. This plan is found mostly in aquatic animals, especially organisms that attach themselves to a base, like a rock or a boat, and extract their food from the surrounding water as it flows around the organism. Bilateral symmetry is illustrated in the same figure by a goat. The goat also has an upper and lower component to it, but a plane cut from front to back separates the animal into definite right and left sides. Additional terms used when describing positions in the body are anterior (front), posterior (rear), dorsal (toward the back), and ventral (toward the stomach). Bilateral symmetry is found in both land-based and aquatic animals; it enables a high level of mobility.

Animals with bilateral symmetry that live in water tend to have a **fusiform** shape: this is a tubular shaped body that is tapered at both ends. This shape decreases the drag on the body as it moves through water and allows the animal to swim at high speeds. lists the maximum speed of various animals. Certain types of sharks can swim at fifty kilometers an hour and some dolphins at 32 to 40 kilometers per hour. Land animals frequently travel faster, although the tortoise and snail are significantly slower than cheetahs. Another difference in the adaptations of aquatic and land-dwelling organisms is that aquatic organisms are constrained in shape by the forces of drag in the water since water has higher viscosity than air. On the other hand, land-dwelling organisms are constrained mainly by gravity, and drag is relatively unimportant. For example, most adaptations in birds are for gravity not for drag.

Most animals have an exoskeleton, including insects, spiders, scorpions, horseshoe crabs, centipedes, and crustaceans. Scientists estimate that, of insects alone, there are over 30 million species on our planet. The exoskeleton is a hard covering or shell that provides benefits to the animal, such as protection against damage from predators and from water loss (for land animals); it also provides for the attachments of muscles.

As the tough and resistant outer cover of an arthropod, the exoskeleton may be constructed of a tough polymer such as chitin and is often biomineralized with materials such as calcium carbonate. This is fused to the animal's epidermis. Ingrowths of the exoskeleton, called **apodemes**, function as attachment sites for muscles, similar to tendons in more advanced animals. In order to grow, the animal must first synthesize a new exoskeleton underneath the old one and then shed or molt the original covering. This limits the animal's ability to grow continually, and may limit the individual's ability to mature if molting does not occur at the proper time. The thickness of the exoskeleton must be increased significantly to accommodate any increase in weight. It is estimated that a doubling of body size increases body weight by a factor of eight. The increasing thickness of the chitin necessary to support this weight limits most animals with an exoskeleton to a relatively small size. The same principles apply to endoskeletons, but they are more efficient because muscles are attached on the outside, making it easier to compensate for increased mass.

Exercise 1. Critical thinking questions.

a. Describe at least two major changes to the animal phylogenetic tree that have come about due to molecular or genetic findings.
b. How is it that morphological data alone might lead scientists to group animals into erroneous evolutionary relationships?
c. Briefly describe at least two theories that attempt to explain the cause of the Cambrian explosion.
d. How is it that most, if not all, of the extant animal phyla today evolved during the Cambrian period if so many massive extinction events have taken place since then?

Exercise 2. Chose the correct answer.

1.As with the emergence of the Acoelomorpha phylum, it is common for ____ data to misplace animals in close relation to other species, whereas ____ data often reveals a different and more accurate evolutionary relationship.

a. molecular : morphological
b. molecular : fossil record

c. fossil record : morphological
d. morphological : molecular

2.Which of the following periods is the earliest during which animals may have appeared?

a. Ordovician period
b. Cambrian period
c. Ediacaran period
d. Cryogenian period

3.What type of data is primarily used to determine the existence and appearance of early animal species?

a. molecular data
b. fossil data
c. morphological data
d. embryological development data

4.The time between 542–488 million years ago marks which period?

a. Cambrian period
b. Silurian period
c. Ediacaran period
d. Devonian period

5.Until recent discoveries suggested otherwise, animals existing before the Cambrian period were believed to be:

a. small and ocean-dwelling
b. small and non-motile
c. small and soft-bodied
d. small and radially symmetrical or asymmetrical

6.Approximately how many mass extinction events occurred throughout the evolutionary history of animals?

a. 3
b. 4
c. 5
d. more than 5

Unit 16. Plant Form and Physiology

needle-leaved conifer	Голчастолиста хвоя
Spruce	Ялина
Photosynthesis	Фотосинтез
Vascular plants	Судинні рослини
Angiosperms	Покритонасінні
Broadleaved trees	Широколисті дерева
Maple	Клен
Oak	Дуб
Elm	В’яз

Meristematic tissue	Меристематична тканина
Permanent tissue	Постійна тканина

Plants are as essential to human existence as land, water, and air. Without plants, our day-to-day lives would be impossible because without oxygen from photosynthesis, aerobic life cannot be sustained. From providing food and shelter to serving as a source of medicines, oils, perfumes, and industrial products, plants provide humans with numerous valuable resources.

When you think of plants, most of the organisms that come to mind are vascular plants. These plants have tissues that conduct food and water, and they have seeds. Seed plants are divided into gymnosperms and angiosperms. Gymnosperms include the needle-leaved conifers—spruce, fir, and pine—as well as less familiar plants, such as ginkgos and cycads. Their seeds are not enclosed by a fleshy fruit. Angiosperms, also called flowering plants, constitute the majority of seed plants. They include broadleaved trees (such as maple, oak, and elm), vegetables (such as potatoes, lettuce, and carrots), grasses, and plants known for the beauty of their flowers (roses, irises, and daffodils, for example).

While individual plant species are unique, all share a common structure: a plant body consisting of stems, roots, and leaves. They all transport water, minerals, and sugars produced through photosynthesis through the plant body in a similar manner. All plant species also respond to environmental factors, such as light, gravity, competition, temperature, and predation.

Like animals, plants contain cells with organelles in which specific metabolic activities take place. Unlike animals, however, plants use energy from sunlight to form sugars during photosynthesis. In addition, plant cells have cell walls, plastids, and a large central vacuole: structures that are not found in animal cells. Each of these cellular structures plays a specific role in plant structure and function.

In plants, just as in animals, similar cells working together form a tissue. When different types of tissues work together to perform a unique function, they form an organ; organs working together form organ systems. Vascular plants have two distinct organ systems: a shoot system, and a root system. The **shoot system** consists of two portions: the vegetative (non-reproductive) parts of the plant, such as the leaves and the stems, and the reproductive parts of the plant, which include flowers and fruits. The shoot system generally grows above ground, where it absorbs the light needed for photosynthesis. The **root system**, which supports the plants and absorbs water and minerals, is usually underground shows the organ systems of a typical plant.

Plants are multicellular eukaryotes with tissue systems made of various cell types that carry out specific functions. Plant tissue systems fall into one of two general types: meristematic tissue, and permanent (or non-meristematic) tissue. Cells of the meristematic tissue are found in **meristems**, which are plant regions of continuous cell division and growth. **Meristematic tissue** cells are either undifferentiated or incompletely differentiated, and they continue to divide and contribute to the growth of the plant. In contrast, **permanent tissue** consists of plant cells that are no longer actively dividing.

Meristematic tissues consist of three types, based on their location in the plant. **Apical meristems** contain meristematic tissue located at the tips of stems and roots, which enable a plant to extend in length. **Lateral meristems** facilitate growth in thickness or girth in a maturing plant. **Intercalary meristems** occur only in monocots, at the bases of leaf blades and at nodes (the areas where leaves attach to a stem). This tissue enables the monocot leaf blade to increase in length from the leaf base; for example, it allows lawn grass leaves to elongate even after repeated mowing.

Meristems produce cells that quickly differentiate, or specialize, and become permanent tissue. Such cells take on specific roles and lose their ability to divide further. They differentiate into three main types: dermal, vascular, and ground tissue. **Dermal tissue** covers and protects the plant, and **vascular tissue** transports water, minerals, and sugars to different parts of the plant. **Ground tissue** serves as a site for photosynthesis, provides a supporting matrix for the vascular tissue, and helps to store water and sugars.

Secondary tissues are either simple (composed of similar cell types) or complex (composed of different cell types). Dermal tissue, for example, is a simple tissue that covers the outer surface of the plant and controls gas exchange. Vascular tissue is an example of a complex tissue, and is made of two specialized conducting tissues: xylem and phloem. Xylem tissue transports water and nutrients from the roots to different parts of the plant, and includes three different cell types: vessel elements and tracheids (both of which conduct water), and xylem parenchyma. Phloem tissue, which transports organic compounds from the site of photosynthesis to other parts of the plant, consists of four different cell types: sieve cells (which conduct photosynthates), companion cells, phloem parenchyma, and phloem fibers. Unlike xylem conducting cells, phloem conducting cells are alive at maturity. The xylem and phloem always lie adjacent to each other. In stems, the xylem and the phloem form a structure called a **vascular bundle**; in roots, this is termed the **vascular stele** or **vascular cylinder**.

Exercise 1. Answer the questions.

1.What is physiology of a plant?

2.What is a plant form?

3. What types of plants do you know?

Exercise 2. Choose the correct answer.

Plant life first appeared on land during which of the following periods?

a. Cambrian period
b. Ordovician period
c. Silurian period
d. Devonian period

Unit 17. Ecology

Organismal ecology	Екологія організмів
Population ecology	Популяційна екологія
Community ecology	Екологія громад
Ecosystem ecology	Екологія екосистем
Producer	Виробник
Consumer	Споживач
Mutualism	Мутуалізм
Symbiosis	Симбіоз
Decomposer	Декомпозитор, розщеплювач
Food chain	Харчовий ланцюг
Habitat	Середовище проживання
biosphere	Біосфера
Ecosystem	екосистема

Why study ecology? Perhaps you are interested in learning about the natural world and how living things have adapted to the physical conditions of their environment. Or, perhaps you're a future physician seeking to understand the connection between human health and ecology.

Humans are a part of the ecological landscape, and human health is one important part of human interaction with our physical and living environment. Lyme disease, for instance, serves as one modern-day example of the connection between our health and the natural world. More formally known as Lyme borreliosis, Lyme disease is a bacterial infection that can be transmitted to humans when they are bitten by the deer tick (*Ixodes scapularis*), which is the primary vector for this disease. However, not all deer ticks carry the bacteria that will cause Lyme disease in humans, and *I. scapularis* can have other hosts besides deer. In fact, it turns out that the probability of infection depends on the type of host upon which the tick develops: a higher proportion of ticks that live on white-footed mice carry the bacterium than do ticks that live on deer. Knowledge about the environments and population densities in which the host species is abundant would help a physician or an epidemiologist better understand how Lyme disease is transmitted and how its incidence could be reduced.

Ecology is the study of the interactions of living organisms with their environment. One core goal of ecology is to understand the distribution and abundance of living things in the physical environment. Attainment of this goal requires the integration of scientific disciplines inside and outside of biology, such as biochemistry, physiology, evolution, biodiversity, molecular biology, geology, and climatology. Some ecological research also applies aspects of chemistry and physics, and it frequently uses mathematical models.

17.1 Levels of Ecological Study

When a discipline such as biology is studied, it is often helpful to subdivide it into smaller, related areas. For instance, cell biologists interested in cell signaling need to understand the chemistry of the signal molecules (which are usually proteins) as well as the result of cell signaling. Ecologists interested in the factors that influence the survival of an endangered species might use mathematical models to predict how current conservation efforts affect endangered organisms. To produce a sound set of management options, a conservation biologist needs to collect accurate data, including current population size, factors affecting reproduction (like physiology and behavior), habitat requirements (such as plants and soils), and potential human influences on the endangered population and its habitat (which might be derived through studies in sociology and urban ecology). Within the discipline of ecology, researchers work at four specific levels, sometimes discretely and sometimes with overlap: organism, population, community, and ecosystem.

17.2 Organismal Ecology

Researchers studying ecology at the organismal level are interested in the adaptations that enable individuals to live in specific habitats. These adaptations can be morphological, physiological, and behavioral. For instance, the Karner blue butterfly (*Lycaeides melissa samuelis*) is considered a specialist because the females preferentially oviposit (that is, lay eggs) on wild lupine. This preferential adaptation means that the Karner blue butterfly is highly dependent on the presence of wild lupine plants for its continued survival.

After hatching, the larval caterpillars emerge and spend four to six weeks feeding solely on wild lupine. The caterpillars pupate (undergo metamorphosis) and emerge as butterflies after about four weeks. The adult butterflies feed on the nectar of flowers of wild lupine and other plant species. A researcher interested in studying Karner blue butterflies at the organismal level might, in addition to asking questions about egg laying, ask questions about the butterflies' preferred temperature (a physiological question) or the behavior of the caterpillars when they are at different larval stages (a behavioral question).

17.3 Population Ecology

A population is a group of interbreeding organisms that are members of the same species living in the same area at the same time. (Organisms that are all members of the same species are called **conspecifics**.) A population is identified, in part, by where it lives, and its area of population may have natural or artificial boundaries: natural boundaries might be rivers, mountains, or deserts, while examples of artificial boundaries include mowed grass, manmade structures, or roads. The study of population ecology focuses on the number of individuals in an area and how and why population size changes over time. Population ecologists are particularly interested in counting the Karner blue butterfly, for example, because it is classified as federally endangered. However, the distribution and density of this species is highly influenced by the distribution and abundance of wild lupine. Researchers might ask questions about the factors leading to the decline of wild lupine and how these affect Karner blue butterflies. For example, ecologists know that wild lupine thrives in open areas where trees and shrubs are largely absent. In natural settings, intermittent wildfires regularly remove trees and shrubs, helping to maintain the open areas that wild lupine requires. Mathematical models can be used to understand how wildfire suppression by humans has led to the decline of this important plant for the Karner blue butterfly.

17.4 Community Ecology

A biological community consists of the different species within an area, typically a three-dimensional space, and the interactions within and among these species. Community ecologists are interested in the processes driving these interactions and their consequences. Questions about conspecific interactions often focus on competition among members of the same species for a limited resource. Ecologists also study interactions among various species; members of different species are called **heterospecifics**. Examples of heterospecific interactions include predation, parasitism, herbivory, competition, and pollination. These interactions can have regulating effects on population sizes and can impact ecological and evolutionary processes affecting diversity.

For example, Karner blue butterfly larvae form mutualistic relationships with ants. Mutualism is a form of a long-term relationship that has coevolved between two species and from which each species benefits. For mutualism to exist between individual organisms, each species must receive some benefit from the other as a consequence of the relationship. Researchers have shown that there is an increase in the probability of survival when Karner blue butterfly larvae (caterpillars) are tended by ants. This might be because the larvae spend less time in each life stage when tended by ants, which provides an advantage for the larvae. Meanwhile, the Karner blue butterfly larvae secrete a carbohydrate-rich substance that is an important energy source for the ants. Both the Karner blue larvae and the ants benefit from their interaction.

17.5 Ecosystem Ecology

Ecosystem ecology is an extension of organismal, population, and community ecology. The ecosystem is composed of all the **biotic** components (living things) in an area along with the **abiotic** components (non-living things) of that area. Some of the abiotic components include air, water, and soil. Ecosystem biologists ask questions about how nutrients and energy are stored and how they move among organisms and the surrounding atmosphere, soil, and water.

The Karner blue butterflies and the wild lupine live in an oak-pine barren habitat. This habitat is characterized by natural disturbance and nutrient-poor soils that are low in nitrogen. The availability of nutrients is an important factor in the distribution of the plants that live in this habitat. Researchers interested in ecosystem ecology could ask questions about the importance of limited resources and the movement of resources, such as nutrients, though the biotic and abiotic portions of the ecosystem.

Career Connection

Ecologist. A career in ecology contributes to many facets of human society. Understanding ecological issues can help society meet the basic human needs of food, shelter, and health care. Ecologists can conduct their research in the laboratory and outside in natural environments. These natural environments can be as close to home as the stream running through your campus or as far away as the hydrothermal vents at the bottom of the Pacific Ocean. Ecologists manage natural resources such as white-tailed deer populations (*Odocoileus virginianus*) for hunting or aspen (*Populus* spp.) timber stands for paper production. Ecologists also work as educators who teach children and adults at various institutions including universities, high schools, museums, and nature centers. Ecologists may also work in advisory positions assisting local, state, and federal policymakers to develop laws that are ecologically sound, or they may develop those policies and legislation themselves. To become an ecologist requires an undergraduate degree, usually in a natural science. The undergraduate degree is often followed by specialized training or an advanced degree, depending on the area of ecology selected. Ecologists should also have a broad background in the physical sciences, as well as a sound foundation in mathematics and statistics.

Exercise 1. Choose the correct answer.

1.The ability of an ecosystem to return to its equilibrium state after an environmental disturbance is called ________.

a. resistance
b. restoration
c. reformation

d. resilience

2.A re-created ecosystem in a laboratory environment is known as a ________.

a. mesocosm
b. simulation
c. microcosm
d. reproduction

3.Decomposers are associated with which class of food web?

a. grazing
b. detrital
c. inverted
d. aquatic

4.The primary producers in an ocean grazing food web are usually ________.

a. plants
b. animals
c. fungi
d. phytoplankton

5.What term describes the use of mathematical equations in the modeling of linear aspects of ecosystems?

a. analytical modeling
b. simulation modeling
c. conceptual modeling
d. individual-based modeling

6.The position of an organism along a food chain is known as its ________.

a. locus
b. location
c. trophic level
d. microcosm

7.The weight of living organisms in an ecosystem at a particular point in time is called:

a. energy
b. production
c. entropy
d. biomass

8.Which term describes the process whereby toxic substances increase along trophic levels of an ecosystem?

a. biomassification
b. biomagnification
c. bioentropy
d. heterotrophy

9.Organisms that can make their own food using inorganic molecules are called:

a. autotrophs
b. heterotrophs
c. photoautotrophs
d. chemoautotrophs

10.In the English Channel ecosystem, the number of primary producers is smaller than the number of primary consumers because________.

a. the apex consumers have a low turnover rate
b. the primary producers have a low turnover rate
c. the primary producers have a high turnover rate
d. the primary consumers have a high turnover rate

11.What law of chemistry determines how much energy can be transferred when it is converted from one form to another?

a. the first law of thermodynamics
b. the second law of thermodynamics
c. the conservation of matter
d. the conservation of energy

12.The movement of mineral nutrients through organisms and their environment is called a ________ cycle.

a. biological
b. bioaccumulation
c. biogeochemical
d. biochemical

13.Carbon is present in the atmosphere as ________.

a. carbon dioxide
b. carbonate ion
c. carbon dust
d. carbon monoxide

14.The majority of water found on Earth is:

a. ice
b. water vapor
c. fresh water
d. salt water

15.The average time a molecule spends in its reservoir is known as ________.

a. residence time
b. restriction time
c. resilience time
d. storage time

16.The process whereby oxygen is depleted by the growth of microorganisms due to excess nutrients in aquatic systems is called ________.

a. dead zoning
b. eutrophication
c. retrofication
d. depletion

17.The process whereby nitrogen is brought into organic molecules is called ________.

a. nitrification
b. denitrification
c. nitrogen fixation
d. nitrogen cycling

Exercise 2. Critical thinking questions.

a. Compare and contrast food chains and food webs. What are the strengths of each concept in describing ecosystems?
b. Describe freshwater, ocean, and terrestrial ecosystems.
c. Compare grazing and detrital food webs. Why would they both be present in the same ecosystem?
d. Compare the three types of ecological pyramids and how well they describe ecosystem structure. Identify which ones can be inverted and give an example of an inverted pyramid for each.
e. How does the amount of food a warm blooded-animal (endotherm) eats relate to its net production efficiency (NPE)?
f. Describe nitrogen fixation and why it is important to agriculture.
g. What are the factors that cause dead zones? Describe eutrophication, in particular, as a cause.
h. Why are drinking water supplies still a major concern for many countries?

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