МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ УКРАЇНИ
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

АНГЛІЙСЬКА МОВА ПРОФЕСІЙНОГО СПРЯМУВАННЯ. ПРИКЛАДНА ФІЗИКА ТА НАНОМАТЕРІАЛИ

English for Professional Purposes. Applied Physics and Nanomaterials

Навчальний посібник

Рекомендовано Методичною радою КПІ ім. Ігоря Сікорського
як навчальний посібник для здобувачів ступеня бакалавра
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Навчальний посібник складається з п’яти розділів професійно орієнтованої тематики, кожен з яких містить автентичні англомовні тексти з розробленим методичним забезпеченням. Особливу увагу приділено розвитку професійних комунікативних навичок (аудіювання, говоріння, читання, письмо) в контексті галузі фізики.

Видання призначене для здобувачів ступеня бакалавра з прикладної фізики та наноматеріалів що матимуть можливість покращити свої мовні навички; використовувати широкий спектр комунікаційних стратегій; підвищити ефективність вивчення англійської мови в аудиторний та позааудиторний час; розвивати творче та критичне мислення; розширити свої знання в галузі фізики та отримати професійні навички.

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Передмова

Навчальний посібник «Англійська мова професійного спрямування. Прикладна фізика та наноматеріали» призначений для навчання професійно орієнтованого англомовного спілкування студентів – майбутніх фахівців у галузі прикладної фізики, які навчаються на бакалавраті (третій курс) технічних університетів.

Метою навчального посібника є формування професійно орієнтованих англомовних компетентностей в аудіюванні, говорінні, читанні та письмі; підвищення ефективності організації навчання іноземної мови в аудиторний і позааудиторний час, а також поглиблення знань професійно орієнтованих дисциплін, розвиток критичного мислення у майбутніх фахівців галузі прикладної фізики.

Перевагою цього навчального посібника є можливість для студентів виконувати вправи онлайн за посиланням або QR-кодом, що підвищує автономію студентів та враховує їхні індивідуально-типологічні особливості, зокрема рівень володіння англійською мовою та навчальний стиль.

Навчальний посібник містить п'ять підрозділів, які охоплюють професійно орієнтовану тематику галузі прикладної фізики («Фізика елементарних частин», «Біофізика», «Оптика і голографія», «Нанотехнології», «Акустика»). Автентичні тексти з веб-сайтів, відео- та аудіоматеріали, книги та статті представляють фаховий, науковий і пізнавальний інтерес для студентів. Кожен підрозділ складається з чотирьох блоків, що орієнтовані на формування професійно орієнтованих англомовних компетентностей у читанні, аудіюванні, говорінні та письмі. Запропоновано виконання вправ різних видів (некомунікативні, умовно-комунікативні, комунікативні) і типів (рецептивні, рецептивно-репродуктивні, рецептивно-продуктивні, продуктивні), а також вправ спрямованих на розвиток критичного мислення, що потребують творчого підходу та прийняття нестандартних рішень. Різноманітність та достатня кількість вправ дозволяють викладачу ефективно організувати аудиторну і позааудиторну роботу студентів.

Протягом опанування навчального матеріалу студенти вчаться застосовувати різні навчальні і комунікативні стратегії (когнітивні стратегії, стратегії запам'ятовування, соціальні стратегії, афективні стратегії, метакогнітивні стратегії, стратегії оволодіння мовними компетентностями, стратегії оволодіння мовленнєвими компетентностями), що дозволяє їм бути гнучкими, організованими та швидко приймати рішення.

Навчальний посібник доповнюється низкою додатків, які містять тексти для читання, міні-словник, граматичний довідник, стенограми аудіо- та відеозаписів, завдання-головоломки, метою яких є надання можливостей студентам самостійно вивчати лексико-граматичні особливості англомовних текстів, використовувати нестандартний підхід до виконання завдань, зацікавити та спонукати студентів до подальшого вивчення англійської мови.

Автентичні матеріали, використані для ефективного навчання і викладання іноземної мови, було взято з різних друкованих та електронних джерел поданих у переліку посилань. На жаль, нам не вдалося простежити деякі джерела, і ми будемо вдячні за будь-яку інформацію, яка дозволила б нам це зробити.

Ми дякуємо усім студентам та колегам, які надали поради та коментарі в процесі розробки навчального посібника. Сподіваємось, що цей посібник дозволить студентам покращити знання з англійської мови професійного спрямування.

Укладачі

Foreword

Textbook “English for Professional Purposes. Applied Physics and Nanomaterials” is designed to teach professionally oriented English communication to students-future professionals in the field of applied physics, who are studying for a bachelor’s degree (third year) of technical universities.

The purpose of the textbook is to form professionally-oriented English-speaking competencies in listening, speaking, reading and writing; improve the efficiency of foreign language learning in the classroom and extracurricular time, as well as to deepen knowledge of professionally oriented disciplines, and develop critical thinking in future professionals in the field of applied physics.

The advantage of this textbook is the opportunity for students to perform exercises online by reference or QR-code, which increases the autonomy of students and takes into account their individual typological characteristics, including the level of English language proficiency and learning style.

The textbook contains five sections covering professionally oriented topics in the field of applied physics (“Particle Physics”, “Biophysics”, “Optics and Holography”, “Nanotechnologies”, “Acoustics”). Authentic texts from websites, video and audio materials, books and articles are of professional, scientific and cognitive interest to students. Each unit consists of four blocks focused on the formation of professionally oriented English-language competencies in reading, listening, speaking and writing. Exercises of different kinds in terms of degrees of cooperation (non-communicative, conditional-communicative, communicative) and difficulty (receptive, receptive-reproductive, receptive-productive, productive) are offered, as well as exercises aimed at developing critical thinking that require creativity and non-standard decision-making. The variety and sufficient number of exercises allow the teacher to organize the classroom and extracurricular work of students effectively.

During the mastering of educational material students learn to apply various educational and communicative strategies (cognitive strategies, strategies of memorization, social strategies, affective strategies, metacognitive strategies, strategies of mastering language competences, strategies of mastering speech competences), which allows them to be flexible, organized and quick at making a decision.

The textbook is supplemented by a number of applications that contain texts for reading, mini-dictionary, grammar guide, transcripts of audio and video recordings, puzzle tasks, which aim to enable students to learn lexical and grammatical features of English texts, use a non-standard approach to tasks, sparkle interest and encourage students to further study English.

Authentic materials used for effective foreign language teaching and learning were taken from various printed and electronic sources listed. Unfortunately, we have not been able to trace some sources, and we would appreciate any information that would allow us to do so.

We thank all the students and colleagues who provided advice and comments in the process of developing the textbook. We hope that this guide will allow students to improve their professional English language skills.

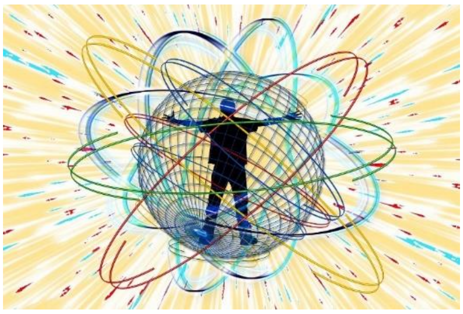
Compilers

UNIT 1. PARTICLE PHYSICS

We know the Higgs field is essential in the formation of stable matter, but the Higgs force – as far as we know – is not.

Matt Strassler, Harvard University theoretical physicist, 2012

Taken from https://www.symmetrymagazine.org/article/where-the-higgs-belongs?language_content_entity=und



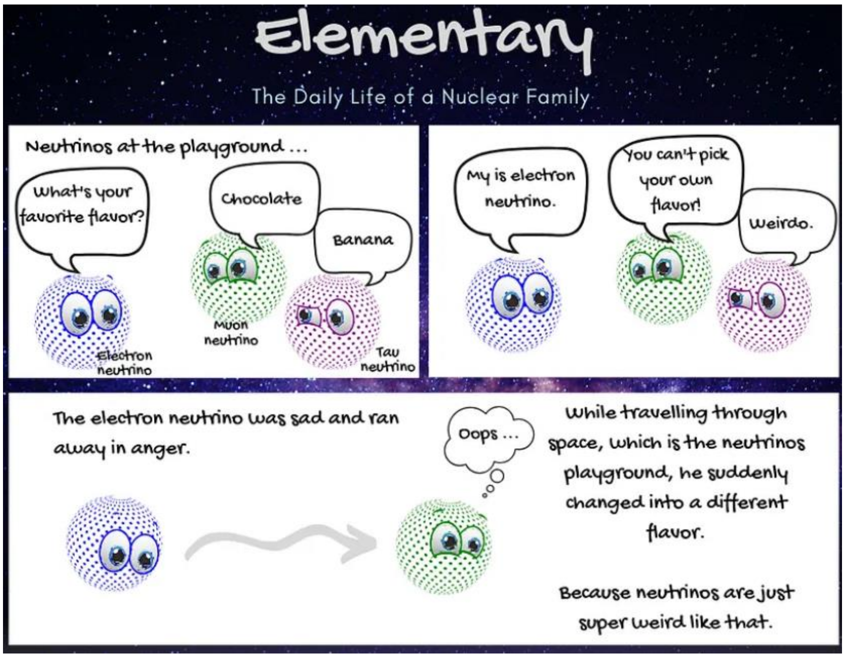
Taken from https://pixabay.com/illustrations/physics-quantum-physics-particles-7854063/

WARM-UP

1. **What do you know about these elements of particle physics?**
   Neutrinos, quarks, protons, leptons, z bosons, w bosons, Higgs bosons, photons, muon neutrinos, tau neutrinos, gluon, graviton.

   Share ideas with your partner. What other particles do you know?

2. **What kind of information can you get from this cartoon? Explain your ideas.**



Taken from https://medium.com/elementary-comic/whats-your-favorite-neutrino-flavor-b69bac8df1c9

3. **Discuss the following quotations in pairs, choose the one you agree with and explain why. Use the phrases:** *I'd go along with that …., this is the case; …, Not only that, but…, you've got the point but…, have you considered…,* **etc.**

1. "Creativity is essential to particle physics, cosmology, and to mathematics, and to other fields of science, just as it is to its more widely acknowledged beneficiaries - the arts and humanities." *Lisa Randall*
2. "Your chemistry high school teacher lied to you when they told you that there was such a thing as a vacuum, that you could take space and move every particle out of it." *Adam Riess*
3. "If I could remember the names of all these particles, I'd be a botanist." *Enrico Fermi*
4. "A man may imagine things that are false, but he can only understand things that are true, for if the things be false, the apprehension of them is not understanding." *Isaac Newton*

Taken from https://www.brainyquote.com/topics/particle-quotes

4. **Match the following pictures to Halloween costumes' descriptions.**

1	2.	3.	4.	5.	6.	7.	8.	9.	10.

1.

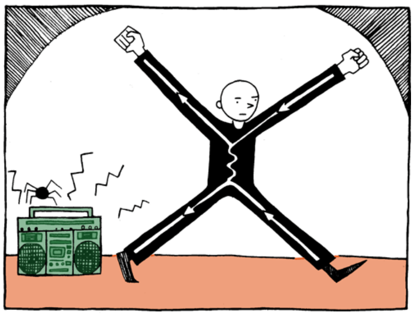
2.

3.

4.

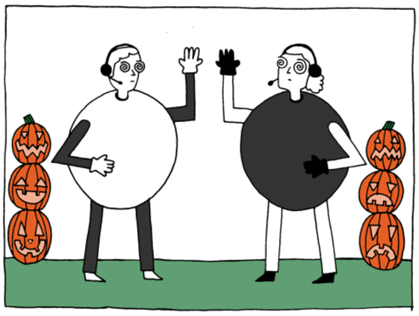
5.

6.



7.

8.



9.

10.

Taken from symmetrymagazine.org/article/october-2014/costumes-to-make-zombie-einstein-proud?language_content_entity=und

Halloween costumes' descriptions

A. Feynman diagram. You might know that a Feynman diagram is a drawing that uses lines and squiggles to represent a particle interaction. Try out this new take on the black outfit/white paint skeleton costume.

B. Bad neutrino. You're a bad neutrino - possibly the worst one in the universe - so you run into everything: lampposts, trees, haunted houses and yes, people. Do a simple white sheet and spend the evening interacting with everyone and everything.

C. Holographic you (niverse). Help others imagine this bizarre concept by printing out a photo of yourself and taping it to your front. You'll still technically be 3-D, but that two-dimensional picture of your face will still start some interesting discussions.

D. Cosmic inflation. Take a simple yellow life vest and draw the cosmos on it: stars, planets, asteroids, whatever you fancy. When friends pull on the emergency tab, the universe will grow.

E. Your favorite physics experiment. You can go as ATLAS (experiment at the Large Hadron Collider/character from Greek mythology), DarkSide (dark matter experiment at Gran Sasso National Laboratory/Darth Vader costume).

F. Dark energy. You are dark energy: a mysterious force causing the accelerating expansion of the universe, intriguing in the lab and perplexing on the dance floor.

G. Your favorite particle. Bring a lamp along to trick-or-treat to go as the photon, carrier of light. Hand out cookies to go as the Higgs boson, giver of mass.

H. Entangled particles. Find someone you are extremely in tune with and dress in opposite colors, like black and white. When no one is observing you, you can relax. But when interacting with people, be sure to coordinate movements.

I. Heisenberg Uncertainty Principle. Put on Walter White's signature hat and shades (or his yellow suit and respirator), but then add some uncertainty by pasting Riddler-esque question marks to your outfit.

J. Antimatter. Break out the bell bottoms and poster board. In bold letters, scrawl the words of your choosing: "I hate things!" "Stuff is awful!".

Taken from symmetrymagazine.org/article/october-2014/costumes-to-make-zombie-einstein-proud?language_content_entity=und

READING

5. **Underline the stressed sound in each word as in the example.**

   Imp<u>o</u>se, menagerie, irreducible, constituent, nucleus, decay, confuse, distinguishable, consequence, trickery, ubiquitous, redundant, imperceptible, reckon, encouraging, compelling.

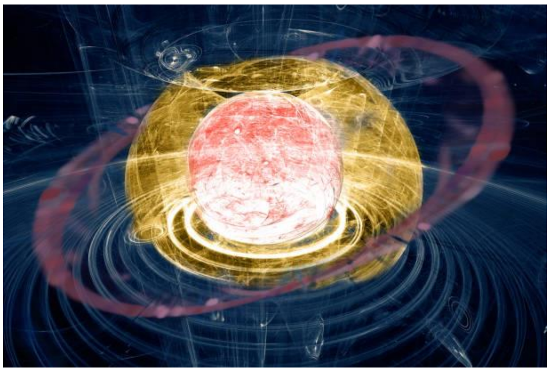
6. **Work in groups of three: students A, B, and C. Discuss the following questions. Student A: read Text A "Particle Physics. New realities?" below. Student B: read Text B "Brave New World", Student C: read Text C "Testing Times" in the EXTRA READING section and see if your answers coincide with the information in the texts.**

1. What is the name of the 18^{th} particle?
2. Why Classical Physics was not good enough for modern scientists?
3. What is the name of CERN's Americal rival?
4. What does the first generation of leptons consist of?
5. What is the quality of a weak boson?
6. Does the Higgs boson have electric or color charge?
7. Which is the most powerful model's force?
8. What are drawbacks of the standard model?
9. How many collisions a second do big particle accelerators create?
10. How many collisions are physicists able to track?

TEXT A

PARTICLE PHYSICS. NEW REALITIES?

A hundred years is a suspiciously round number. But if researchers at CERN, the European particle-physics laboratory near Geneva, turn out to be correct, it is exactly the period needed to build a model of how the universe works. Construction began in1900



Taken from istockphoto-471931693-612x612.jpg

with Max Planck's publication of the first incarnation of quantum theory.

Since then, and particularly with the development of high-energy particle accelerators in the 1930^s and 1940^s, the structure of matter has been probed in greater and greater detail while theorists have sought to impose order on what has been discovered. The result of their labors, now known as the standard model, will be complete – bar the odd dotting of "i"s and crossing of "t"s – with the discovery of a particle called the Higgs boson. This would round off the 18-strong menagerie of fundamental, irreducible particles required by the model. The 17th, known as the tau neutrino, was announced two months ago by researchers at CERN's American rival, Fermilab. And over the past few weeks, indications have emerged from CERN that the Higgs is indeed a reality.

Discovering the Higgs would be an impressive piece of work. Historians of science may, however, pause at this point. For it sounds suspiciously like the consensus that prevailed at the end of the 19th century, just before the publication of Planck's paper. Then, too, physicists had a description of the universe that had few apparent flaws. Some of the more hubristic thought the job was done and that the science they had created was, in effect, a "theory of everything".

But it wasn't. Classical physics, as it is now called, turned out to be a mere engineer's approximation to reality – good enough for everyday work, but explaining nothing fundamental. Today, physicists are more cautious. Few believe that the standard model is a theory of everything, but none knows for certain what the next step – the equivalent of Planck's paper – will actually be. That, however, makes the future of physics much more exciting. For the first time in several decades (assuming that the world's taxpayers will continue to fork out for the necessary equipment) fundamental physics will become a voyage into the unknown.

Taken from https://www.economist.com/science-and-technology/2000/10/05/new-realities

7. **Decide whether the following statements are True or False.**

1.	2.	3.	4.	5.	6.	7.	8.

1. The 17th particle is known as the tau neutrino.

2. The 18 particles are divided into fermions and bosons.

3. Photons carry the electromagnetic force, the strongest in the standard model, and have no mass.
4. The Higgs boson has electric charge, and so it affects only the weak force.
5. The standard model succeeded in accounting for gravity.
6. Using big accelerators, physicists can track and record about 10 million collisions a second.
7. "Sleuth" was another high-energy particle accelerator.
8. According to Dr. Womersley, the standard model will not exist within the next five years.

8. Work in pairs and see if you can remember the following words and phrases. Take turns to describe each word and ask each other.

incarnation	impressive
impose	consensus
menagerie	prevail
irreducible	flaw
rival	hubris
emerge	mere
cautious	constituent
exciting	quark
assuming that	flavor
fork out	charm
fermion	thus
approximation	constituents
intruder	stepping-stone
accelerator	particle

USE OF ENGLISH

9. Select definitions (a–j) from the list to match the key terms (1-10)

1. boson	a) the natural chemical change that causes the slow destruction of something;
2. apparent	b) the use of something to deceive or cheat people;
3. nucleus	c) to make someone feel that they cannot think clearly or do not understand;
4. decay	d) a particle that follows Bose-Einstein statistics and makes up one of the two classes of particles;
5. confuse	e) very unusual or strange;
6. distinguishable	f) easy to recognize as being different from something else;
7. kludge	g) the light or heat is sent out in all directions;
8. trickery	h) seeming to have a particular feeling or attitude, although this may not be true;
9. radiate	i) something that is made or written very quickly and not very well;
10. bizarre	j) the central part of an atom made up of neutrons, protons, and other elementary particles.

10. Find the synonyms to the following words in the text.

1. building (para. 1); ***construction***
2. to force (para. 1);
3. space (para. 2);
4. small (para. 3);
5. careful (para. 3);
6. collaborate (para. 4);
7. essentials (para. 5);

8. common (para. 6);
9. ruination (para. 6);
10. effect (para. 7)

11. In the text find the opposite of the following words.

Destroy – ***build*** (para. 1); superficial – ____ (para. 2); practitioners – ____ (para. 2); fiction – ____ (para. 2); friend – ____ (para. 2); humble – ____ (para. 3); virtue – ____ (para. 3); reckless – ____ (para. 4); dull – ____ (para. 4); withhold – ____ (para. 4).

12. Fill in the gaps with the words from exercise 10. You may need to change the form of some words.

1. Keller is ***cautious*** about making predictions for the success of the program.
2. It can't be a ____ coincidence that they left at the same time.
3. Beggars on the street are becoming a ____ sight.
4. The court can ____ a fine.
5. Many believe that poverty is a direct ____ of overpopulation.
6. Work out the exact design before you start ____.

13. Fill in the gaps in the sentences below with the correct word from the box.

interactions, bosons, mass, particles, The Higgs, multiplying, energy, quarks, determined, effects

A problem of mass

The Higgs mechanism gives (1) ***mass*** to some fundamental particles, but not others. It interacts strongly with W and Z (2) ____, making them massive. But it does not interact with (3) ____ of light, leaving them massless.

These (4) ____ don't just affect the mass of other particles, they also affect the mass of the Higgs. (5) ____ can briefly fluctuate into virtual pairs of the particles with which it interacts.

Scientists calculate the mass of the Higgs by (6) ____ a huge number – related to the maximum (7) ____ for which the Standard Model applies – with a number related to those fluctuations. The second number is (8) ____ by starting with the effects of fluctuations to force-carrying particles like the W and Z bosons and subtracting the (9) ____ of fluctuations to matter particles like (10) ____.

14. Match the key terms (1-10) with their definitions (a-j).

1. Subatomic particles	**a)** An elementary particle and a fundamental constituent of matter comprising composite particles, the most stable of which are protons and neutrons.
2. Electron	**b)** An elementary particle, the quantum of all forms of electromagnetic radiation, including light.
3. Proton	**c)** An elementary particle with half-integer spin, that interacts only via the weak subatomic force and gravity.
4. Neutron	**d)** An elementary particle similar to the electron, with an electric charge of −1 *e* and a spin of ½, but with a much greater mass.
5. Quark	**e)** Particles, which are much smaller than atoms
6. Photon	**f)** A subatomic particle, symbol e− or β−, with a negative elementary electric charge
7. Neutrino	**g)** A subatomic particle, symbol p or p+, with a positive electric charge of +1e elementary charge and mass slightly less than that of a neutron

8. Muon	**h)** A subatomic particle, symbol n, with no net electric charge and a mass slightly larger than that of a proton.
9. Fermion	**i)** A particle that follows Bose-Einstein statistics.
10. Boson	**j)** Any particle characterized by Fermi-Dirac statistics.

15. Choose the best word from each pair in bold to complete the sentence.

1. When physicists discovered ***<u>the Higgs boson</u>*** **/ electron** in 2012, they declared the Standard Model of particle physics complete; they had finally found the missing piece of the particle puzzle.
2. The Higgs mechanism gives **mass / number** to some fundamental particles.
3. The particle interacts strongly with W and Z **bosons / protons**, making them massive.
4. The Higgs can briefly **fluctuate / oscillate** into virtual pairs of the particles with which it interacts.
5. Scientists calculate the mass of the Higgs by **multiplying / dividing** a huge number with a number related to those fluctuations.
6. The second number is determined by starting with the effects of fluctuations to **force / velocity-carrying** particles like the W and Z bosons, and subtracting/multiplying the effects of fluctuations to matter particles like quarks.
7. If there are multiple Higgses – much heavier ones – the math determining their **masses / volumes** becomes more flexible.
8. Supersymmetry predicts a **heavier / easier** partner particle, or "sparticle" for each of the known fundamental particles.
9. The Minimal Supersymmetric Standard Model – the supersymmetric model that most/least closely aligns with the current Standard Model – predicts four new Higgs **particles / debris** in addition to the Higgs particle, the Higgsino.
10. If Supersymmetry exists, scientists will need to **produce / destroy** more massive particles to observe it.

16. There is an odd word in each line. Find it and write in the space provided.

1. The other popular **also** theory that predicts multiple Higgs	***also***
2. bosons is compositeness. The composite Higgs theory is	
3. proposes that the Higgs boson is not an fundamental particle	
4. but is instead made of smaller little particles that have not yet	
5. been discovered. As people looked after closer and closer,	
6. they found again the proton and neutron. They looked closer	
7. again and found the 'up' and 'down' quarks that make up off	
8. the proton and neutron. Composite Higgs theories are predict	
9. that if there are more fundamental parts in to the Higgs, it may	
10. assume a combination of many masses based on the	
11. properties of these more smaller particles.	

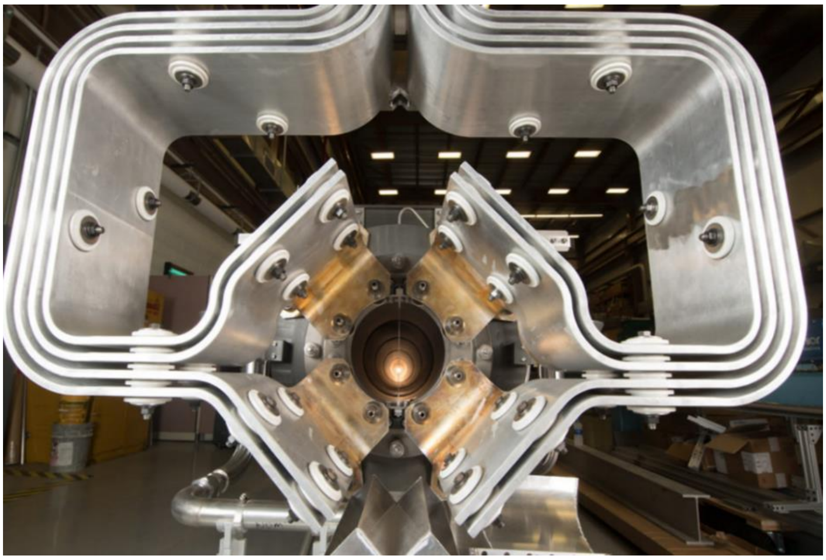
17. Put the verbs in brackets into the correct (infinitive or -ing) form.

1. According to the Standard Model of particle physics, neutrinos were originally thought ***to have*** (**HAVE**) no mass.
2. As massless particles, neutrinos wouldn't be able ____ (**CHANGE**) their handedness.
3. Until now, scientists have only observed left-handed neutrinos, but the right-handed version might ____ (**LURK**) out of sight.
4. While left-handed neutrinos interact in two ways, right-handed neutrinos are even trickier, ____ (**INTERACT**) perhaps only through gravity.
5. Any two measurements should allow scientists ____ (**PREDICT**) the third discovering that it didn't exist would have rewritten the path of particle physics.

18. Fill in the gaps with the correct preposition from the box.

at, with, below, from, through, inside, at, of, in, into

The World's Most Powerful Neutrino Beam



To tackle the biggest questions, DUNE will look (1) ***at*** mysterious subatomic particles called neutrinos: neutral, wispy wraiths that rarely interact with matter. Because neutrinos are so antisocial, scientists will build enormous particle detectors to catch and study them. More matter (2) ____ the DUNE detectors means more things for neutrinos to interact (3) ____, and these behemoth neutrino traps will contain a total (4) ____ 70,000 tons of liquid argon. (5) ____ their home 1.5 kilometers (6) ____ the rock in the Sanford Underground Research Facility (7) ____ South Dakota, they'll be shielded (8) ____ interfering cosmic rays. However, neutrinos will have no trouble passing (9) ____ that buffer and hitting their mark. The detectors can pick up neutrinos from exploding stars that might evolve (10) ____ black holes and capture interactions from a deliberately aimed beam of neutrinos.

Text and image taken from https://www.symmetrymagazine.org/article/how-do-you-make-the-worlds-most-powerful-neutrino-beam?language_content_entity=und

19. Match the idioms in the left-hand column with their definitions in the right-hand column.

1	through thick and thin	***a***	to have information about something secret
2	bounce off the walls	***b***	to have problems
3	once in a blue moon	***c***	smart, extremely clever,
4	get wind of something	***d***	make a guess based on what you have heard or seen
5	go down in flames	***e***	at all times, good or bad
6	a weighty situation	***f***	a sudden increase in the size, amount, or quality
7	to be light years ahead	***g***	very rarely
8	a quantum leap/jump	***h***	both things are equal
9	put two and two together	***j***	to fail, to lose something
10	six of one and half a dozen of the other	***k***	to be extremely excited and energetic

Taken from https://english-at-home.com/idioms-with-numbers/

20. Fill in the table with the words derived from the given ones.

Verb	**Noun**	**Adjective**	**Adverb**
validate	***validity, validation***	valid	***validly***
X	consequence	…	…
X	X	early	…

Verb	Noun	Adjective	Adverb
…	…	…	imposingly
…	familiarity	…	…
search	…	…	…
…	…	…	noticeably
…	knowledge	…	…
pass	…	…	…
…	…	…	…

Taken from https://dictionary.cambridge.org/dictionary/english/

21. Fill in the blanks with the words derived from the words in bold.

When physicists finally detected the Higgs boson in 2012, they (1) ***validated*** (**VALIDITY**) a theoretical prediction made some 50 years (2) __________ (**EARLY**). But not every particle that physicists (3) ____________ (**SEARCH**) for has such a history. Several experiments (4) ________ (**BE**) on the hunt for a particle that theory never demanded – but that (5) _________ (**CAN**) wind up answering several open questions in particle physics. (6) __________ (**KNOW**) as a sterile neutrino, the particle is an even (7) ________ (**SNEAKY**) version of the ghostly neutrino. Neutrinos stream through other matter almost completely (8) __________ (**NOTICE**); about 100 trillion of them (9) ________ (**PASS**) through your body every second, though only (10) ________ (**FEWEST**) will interact in your body over your entire lifetime.

Taken from https://www.symmetrymagazine.org/article/the-hidden-neutrino?language_content_entity=und

22. Match the parts of the sentences from two columns to make correct sentences.

1. According to our current understanding,	a. an invisible field called the 'Higgs field' was formed.
2. As the Universe cooled and the temperature fell below a critical value,	b. between the massless photon and the massive W and Z boson.
3. Particles such as the W and Z bosons acquire mass through their interaction with this field –	c. all particles were massless just after the Big Bang.
4. The existence of the Brout-Englert-Higgs field explains the difference	d. the LHC experiments search for its manifestation, the particle.
5. Other force-carrying particles – the photon and the gluon – do not have	e. with the Higgs field.
6. The Higgs boson is the quantum particle associated	f. the more intensely they interact, the heavier they become.
7. Since the field cannot be observed directly,	g. an interaction with the Higgs field and remain massless.

Taken from https://cmsexperiment.web.cern.ch/physics/higgs-boson

23. Put the words in brackets into the correct form.

1. Experimentalists ***found*** (**find**) the first hint of the existence of sterile neutrinos two decades ago.
2. If there ____ (**to be**) three neutrino states, as described in the Standard Model, then there should be three different kinds of oscillations that can be measured.
3. Any two measurements should allow scientists ____ (**predict**) the third.
4. By the early 2000s, physicists ____ (**hope**) to confirm the last measurement with experiments run at Los Alamos' Liquid Scintillator Neutrino Detector.
5. LSND's results ____ (**to be**) so surprising that physicists built a new detector at Fermilab to check their findings.

6. The detector picked up an excess of electron neutrinos in 2006 that conflicted with LSND's results but still ____ (**indicate**) the possibility of sterile neutrinos.
7. To further ____ (**probe**) these excesses, physicists need to look at interactions in multiple detectors set at different distances from the neutrino source.
8. Even with these new detectors, ____ (**find**) definitive evidence of the existence of sterile neutrinos will be a challenge.
9. The "sterile" in the name of neutrinos comes from their inability ____ (**interact**) with other matter through any of the forces in the Standard Model other than perhaps gravity.
10. At LSND, fewer than one in 1 trillion neutrinos will interact with another particle, ____ (**leave**) a footprint for scientists to measure.

Taken from https://www.symmetrymagazine.org/article/the-hidden-neutrino?language_content_entity=und

24. Choose the correct option.

1. Our solar system, ***a*** one-star system of nine planets, was formed approximately 4.5 million years ago.

   A a **B** an **C** the **D** -

2. How did life form? Was it ____ lightning flash?

   A a **B** an **C** the **D** -

3. The corrosion of silver ____ silver sulphide.

   A produce **B** producing **C** produces **D** is produced

4. The woman ____ he heard at the conference is a famous particle physicist.

   A which **B** whom **C** whose **D** where

5. Smog formation is a process that scientists ____.

   A is investigating **B** investigates **C** investigating **D** investigate

6. What to do in an emergency ____ on the container.

   A are described **B** are describing **C** is described **D** described

7. A seismometer ____ earthquakes.

   A measures **B** measuring **C** is measured **D** measure

8. ____ metal used for construction is aluminum.

A The lighter **B** The lightest **C** The most light **D** The more light

9. Silicate dust ____ the sun forms a ring two million kilometers wide.

A surrounds **B** surrounded **C** surround **D** surrounding

10. Two groups have successfully used solar energy ____ water.

A splitting **B** to split **C** splitted **D** split

Taken from Master, P. (2004). English Grammar and Technical Writing. Office of English Language Programs, Washington. p. 269, 272, 273, 274, 278, 281, 283, 286

TRANSLATION

25. Choose the correct option.

1. Фізик Абгі Дасгупта залишив кар'єру в науці, оскільки хотів досягти балансу між роботою та особистим життям.

A. Physicist Abhi Dasgupta left a career in science because he avoided to achieve a work-life balance.

B. Physicist Abhi Dasgupta left a career in science because he wanted to achieve a work-life balance.

C. Physicist Abhi Dasgupta left a career in physics because he wanted to keep a work-life balance.

2. Магістерські програми з фізики не передбачають ознайомлення студентів з можливостями працевлаштування за межами дослідницьких установ.

A. Master's programs in physics did not expose students to careers outside of research institutions.

B. Master's programs in physics expose students to careers outside of research institutions.

C. Master's programs in physics do not expose students to careers outside of research institutions.

3. Після завершення докторської програми Дасгупта почав шукати інші можливості працевлаштування.

A. Having completed his doctoral program, Dasgupta began looking for other employment options.

B. After completing his doctoral program, Dasgupta began looking for other employment options.

C. While completing his doctoral program, Dasgupta began looking for other employment options.

4. Дасгупта розпочав семитижневу програму одразу після захисту докторської дисертації у 2019 році.

A. Dasgupta began the seven-week program immediately after completing his PhD in 2019.

B. Dasgupta began the seventh program immediately after completing his PhD in 2019.

C. Dasgupta had begun the seven-week program immediately before completing his PhD in 2019.

5. Фізики вміють отримувати величезну кількість необроблених даних і використовувати їх для вирішення проблем.

A. Physicists wonder how to sift through the enormous amount of raw data and use it to solve problems.

B. Physicists know how to obtain the enormous amount of raw data and use it to solve problems.

C. Physicists wonder how to process the enormous amount of raw data and use it to solve problems.

Taken from https://www.symmetrymagazine.org/article/the-data-wranglers?language_content_entity=und

SPEAKING

26. Work in pairs. Read Text D "DO HIDDEN INFLUENCES GIVE NEUTRINOS THEIR TINY MASS?" (see Appendix 1, Extra Reading section to Unit 1). Write three questions based on Text D and fill in the table. Ask other students and note their answers. Compare the results with your partner.

	STUDENT 1 ______________	STUDENT 2 ______________	STUDENT 3 ______________
Q.1.			
Q.2.			
Q.3.			

27. Answer the question: if we could time travel, where would you go? Why? Share your ideas with your partner and compare your answers with Stephen Hawking's point of view.

According to Stephen Hawking, particle accelerators are the closest things we have to time machines. In 2010, physicist Stephen Hawking wrote an article for the UK paper *The Daily Mail* explaining how it might be possible to travel through time. We would just need a particle accelerator large enough to accelerate humans the way we accelerate particles, he said. A person-accelerator with the capabilities of the Large Hadron Collider would move its passengers at close to the speed of light. Because of the effects of special relativity, a period of time that would appear to someone outside the machine to last several years would seem to the accelerating passengers to last only a few days. By the time they stepped off the LHC ride, they would be younger than the rest of us.

Taken from https://www.symmetrymagazine.org/article/april-2014/ten-things-you-might-not-know-about-particle-accelerators?language_content_entity=und

28. **Look at the words and phrases below. With your partner, recall how they were used in the text and prepare a five-minute report on particle physics including them:**

CERN, Classical Physics, the Higgs boson, the 18 particles, the first generation of leptons, weak boson, a mathematically symmetrical process.

LISTENING

29. **Before listening to the podcast "Groundwater Pumping", check the meaning of the following words and phrases:**

underground reservoir, extract groundwater, the tilt of Earth's axis, drift by, cause Earth to wobble, the rotation axis, depletion of underground water.

30. **Scan the QR code. Listen to the podcast "Groundwater Pumping" and decide whether the statements are true (*T*) or false (*F*).**

1.	2.	3.	4.	5.

1. Underground reservoirs affect the balance of the Earth.
2. The pumping of groundwater is moving the North Pole.
3. The article says groundwater does not affect gravity.
4. Scientists knew groundwater affected Earth's axis centuries ago.
5. Most groundwater pumped out of the ground is for irrigation.

Taken from https://breakingnewsenglish.com/2306/230619-earths-axis.html

31. Listen to the podcast "Groundwater Pumping" for the second time and complete the sentences.

1. This shift has been significant enough to physically ____ the geographic North Pole.
2. Professor Seo calculated that we extracted more than two trillion tons of ____ between 1993 and 2010.
3. Professor Seo explained how groundwater affects Earth's ____.
4. Scientists have only ____ discovered how groundwater can change Earth's axis.
5. They concluded that the ____ of underground water was also a factor.

Taken from https://breakingnewsenglish.com/2306/230619-earths-axis.html

32. Before listening to the podcast "A Zeptosecond", check the meaning of the following words and phrases:

a tiny fraction, a hydrogen molecule, femtosecond, millisecond, nanosecond, the speed of light, measure, sense, followed by, a decimal point.

33. Scan the QR code. Listen to the podcast "A Zeptosecond" and decide whether the statements are true (*T*) or false (*F*).

1.	2.	3.	4.	5.

1. A zeptosecond is a billionth of a trillionth of a second.
2. It took a photon 247 zeptoseconds to cross a hydrogen molecule.
3. An Egyptian physicist won the 1999 Nobel Prize in Chemistry.

4. The time it takes for a neuron in the human brain to fire is a millisecond.
5. The time unit called a Planck is a decimal point followed by 100 zeros.

Taken from https://breakingnewsenglish.com/2010/201020-zeptosecond.html

34. Listen to the podcast "A Zeptosecond" for the second time and complete the sentences.

1. They recorded the ____ unit of time ever measured.
2. The scientists study ____ physics at the Goethe University in Germany.
3. This is too small for the ____ eye to see.
4. This is a decizmal point followed by ____ zeros and then a 1.
5. This is the time for a neuron in the human brain to ____.

Taken from https://breakingnewsenglish.com/2010/201020-zeptosecond.html

WRITING

35. Write a summary of the text (20 words).

Monte Carlo simulations

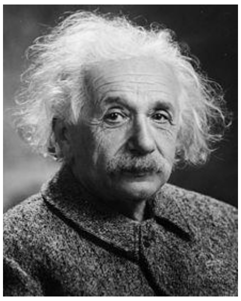
Originally developed nearly a century ago by physicists studying neutron diffusion, Monte Carlo simulations are mathematical models that use random numbers to simulate different kinds of events. As a simple example of how they work, imagine you have a pair of six-sided dice, and you'd like to determine the probability of the dice landing on any given number. "You take your dice, and you repeat the same exercise of throwing them on the table, and you look at the outcome," says Susanna Guatelli, associate professor of physics at the University of Wollongong in Australia. By repeating the dice-throwing experiment and recording the number of times your dice land on each number, you can build a "probability distribution" — a list giving you the likelihood your dice will land on each possible outcome. For the Monte Carlo simulations used in physics, "we repeat the same experiment many, many times," Guatelli says. "When we use it to solve problems, we have to repeat the same experiment that, of course, is a lot more difficult and complex than throwing the dice."

Much like the universe itself, Monte Carlo simulations are governed by randomness and chance. This makes them well suited to modeling natural systems. "A Monte Carlo simulation is basically our way of simulating nature," says Benjamin Nachman, a staff scientist at the US Department of Energy's Lawrence Berkeley National Laboratory.

Taken from https://www.symmetrymagazine.org/article/will-ai-make-mc-the-mvp-of-particle-physics?language_content_entity=und

36. Write an abstract of Text E "THE SEARCH FOR THE STERILE NEUTRINO" (see Appendix 1, Extra Reading section to Unit 1). You may use the suggested phrases: *the text is devoted to …; this text concentrates on …; it is shown …; it is reported …; it is studied …; the results show ….*

37. Here are the portraits of the people who have changed the history of the modern particle physics. Who is the third remarkable person to be named in this row? Write 5−7 sentences to present the person and their contribution to physics.



?

Taken from https://pixabay.com/photos/albert-einstein-portrait-1933340/
https://ua.wikipedia.org/wiki/Склодовська-Кюрі,_Марія

38. A. Play the role of a magazine correspondent. You are given the task to write an article (up to 180 words) about the future of particle physics discoveries. Some of the questions should be reflected in your article.

Start it with "The Standard Model answers many of the questions about the structure and stability of matter with its six types of quarks, six types of leptons, and four forces. But the Standard Model is not complete; there are still many unanswered questions: why do we observe matter and almost no antimatter if we believe there is symmetry between the "two in the universe"? What is this dark matter that we can't see that has visible gravitational effects in the cosmos? How does gravity fit into all of this?"

EXTRA READING

39. Read Text F "DINGO THERMAL NEUTRON" (see EXTRA READING section to Unit 1) and decide whether the statements are true (T) or false (F) according to the text.

1.	2.	3.	4.	5.

1. Dingo is the only thermal neutron imaging beamline available in Austria.
2. Analytical optimization for Dingo is not challenging.
3. A Monte Carlo simulation model uses a more practical approach.
4. The "digital twin" would be available only to beamline scientists.
5. There are similar models of other neutron beamlines.

40. Read Text F "DINGO THERMAL NEUTRON" (see EXTRA READING section to Unit 1). Fill in the blanks (1-5) with the appropriate headings (A - D) from the list below.

A. Versatile Applications
B. Critical Importance of Dingo
C. Optimizing Experiments: a Digital Twin
D. Other Similar Models

41. Read Text E "THE SEARCH FOR THE STERILE NEUTRINO" (see EXTRA READING section to Unit 1) and decide whether the statements are true (T) or false (F) according to the text.

6.	7.	8.	9.	10.

1. In beta decay, a stable atom releases energy in the form of a beta particle.
2. Some scientists were optimistic about detecting the neutrino.
3. The ability of the neutrino to "oscillate" implied it had mass.
4. In 2011, the theorists discovered that their prediction was accurate.
5. Whatever the results of the research are, it is beneficial for science.

42. Read Text E "THE SEARCH FOR THE STERILE NEUTRINO" (see EXTRA READING section to Unit 1). Fill in the blanks (1-5) with the appropriate headings (A - E) from the list below.

A. Experiments on the horizon
B. More than meets the eye
C. A dare prediction
D. Conflicting anomalies
E. Experiments on the horizon

43. Read Text D "DO HIDDEN INFLUENCES GIVE NEUTRINOS THEIR TINY MASS?" (see EXTRA READING to Unit 1) and decide whether the statements are true (T) or false (F).

1.	2.	3.	4.	5.

1. The Standard Model of particle physics explains how neutrinos get their mass.
2. All neutrinos are right-handed.
3. According to the seesaw model, neutrinos have two eigenvalues,

4. The predicted particles are too massive for physicists to study them.
5. The physics of neutrino mass is as mysterious as the physics of dark matter.

44. Read Text D "DO HIDDEN INFLUENCES GIVE NEUTRINOS THEIR TINY MASS?" (see EXTRA READING to Unit 1). Fill in the blanks (1-5) with the appropriate headings (A - E) from the list below.

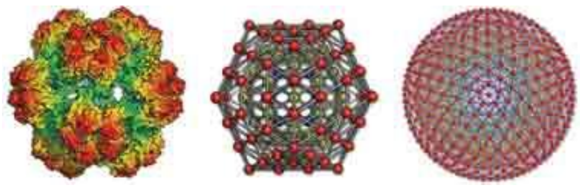
E. To get a new particle, use a seesaw
F. Undiscovered particles
G. Gaining mass the Higgs field way
H. A seesaw mechanism
I. A need to check everywhere – and ask the right questions

PROBLEM-SOLVING

45. Do the quiz (see the PROBLEM-SOLVING section for Unit 1).

UNIT 2. BIOPHYSICS

"Biophysics is not a trivial merging of biology and physics, nor is it the application of physical techniques to biological problems." ***Robin Corey***



Taken from http://www.yorku.ca/cberge/4090images/what.is.biophysics.brochure.pdf

WARM-UP

1. What does biophysics study? Share ideas with your partner using the phrases from the table below.

Asking about or for an opinion	**Giving your opinion**
Could you tell me ...?	In my opinion / view ...
What do you think about / of ...?	If you ask me ...
What's your opinion about ...?	As far as I can see / I'm concerned ...
Do you think / feel ...?	It seems to me that ...
How do you feel about ...?	I think / feel / reckon / believe ...
May I ask you ...?	If you want my opinion ...
	What we have to decide is ...
	There can be no doubt that ...
	It's a fact that ...
	Nobody will deny that ...
Agreeing with an opinion	**Polite disagreement**
I (quite) agree.	I disagree (with you), I'm afraid.
I agree completely / entirely.	No, I really can't agree, I'm afraid.
I couldn't agree (with you) more.	I don't quite agree there.
I entirely/completely agree with you on that.	I'm not so certain / at all sure if that's true / correct
That's just it.	I'm not (quite) so sure (really).
I think so, too.	I'm sorry I can't agree.
That's a very good / important point.	Do you really think so / believe that?

You've got a good point there. Yes, of course / definitely / absolutely That's exactly what I mean / say. That's exactly how I see it. Yes, indeed. I'm all in favour of what you've been saying.	I'm not convinced that ... Well, that's one way of looking at it, (but) Well, I have my doubts about that You don't really mean that, do you? I wouldn't say so. I don't think so. I don't want to argue with you, but ...

2. What disciplines are related to biophysics? Match the sciences (1-8) with their definitions (a-h).

1) Biochemistry and Chemistry	a) These deal with neural networks examined experimentally (brain slicing, for example) as well as with theory (computer models), membrane permeability, gene therapy and cancer research.
2) Biology and Molecular Biology	b) This deals with high-resolution structures of proteins, nucleic acids, lipids and carbohydrates.
3) Computer Science	c) This deals with graph/network theory and population modelling.
4) Mathematics	d) This deals with molecular simulations, neural networks and databases.
5) Medicine and Neuroscience	e) These deal with biomolecular structure, nucleic acid structure and structure-activity relationships.
6) Pharmacology and Physiology	f) This deals with biomolecular free energy, biomolecular structures and dynamics, protein folding and surface dynamics.
7) Physics	g) These deal with membrane channel biology, biomolecular interactions and cellular membranes.
8) Structural Biology	h) These deal with gene regulation, single-protein dynamics, bioenergetics and biomechanics.

3. Discuss the following quotations in pairs / small groups. Which quotation is closer to your own ideas?

A. “The employment of physical instruments in a biological laboratory does not make one a biophysicist-otherwise any user of a microscope, a balance, an x-ray equipment, a Geiger counter, or a pH meter, would drop automatically into that class.”

Archibald Hill (Nobel Laureate)

B. “Biophysics to me has always been applying the physics mentality and skillset to problems in biology.”

Christopher Van Lang

C. “Biophysics is the study of physical phenomena in biological systems. For example, photosynthesis is a process that involves quantum mechanics (absorption of light resulting in electron transfer). The strength of plant fibres (e.g., cotton) is modelled using ideas from classical mechanics. And so on.”

Steve Schafer

D. “Biophysics is an interdisciplinary science that applies the approaches and methods of physics to study biological systems.”

George Hurley

E. “We have had some biophysicists come to bioinformatics. Their work was quite similar to ours except they used more maths. So, the field in general may not be defined as physics methods applied to biology, but I know some examples of research that would satisfy that description.”

Simon Rasmussen

F. “Life is a recurring process of the body getting energy in order to execute actions. The body is here a biophysical system which converts food energy into mechanical energy.”

Amit Kumar Verma

4. What are the main topics that biophysics covers? Discuss in pairs how to apply biophysics to the following questions.

1. How much do you need to eat?
2. How to make an equation of work done, body weight, muscle, fat, how big the stomach is, what sports or activities will be done, etc.
3. What number of chemical processes will speed up the enzymes? For how long and how effectively?
4. How much anaesthesia does this patient need? If I put in too much, will they die or something? If I put in too little, will they wake up, see the gore, and die or something?

READING

5. Underline the stressed syllable in each word as in the example. Practise reading:

apply, interdisciplinary, structures, properties, sugar, macromolecule, elongate, microscope, consciousness, perception, deoxyribonucleic, biophysicist, crystallography, manipulate.

6. Fact or fiction? Try to do the quiz in pairs. Explain your answers.

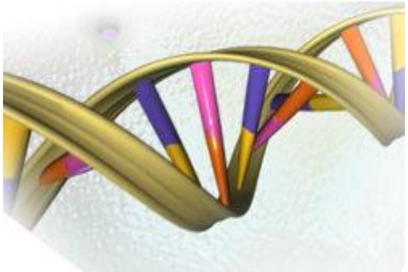
1. Abegg's law has to do with the number 8.
2. The concept of cell biology is a very ancient one.
3. Atoms are invisible.
4. Enzymes are catalysts.
5. There are only one or two kinds of atoms.
6. Water must go from solid to liquid before becoming a gas.
7. The mass of an iron atom is much higher than that of a uranium atom.
8. Fire requires oxygen.
9. Molecules in a hot gas move more rapidly than those in a cooler gas.
10. Abzymes speed up chemical reactions.

7. **Study these definitions of biophysics (/ˌbaɪ oʊˈfɪz ɪks/) from the different dictionaries. Which is the most scientific? Why?**
    1. The branch of biology that applies the methods of physics to the study of biological structures and processes (Collins).
    2. Biophysics is a branch of science concerned with the application of physical principles and methods to biological problems (Merriam Webster).
    3. Biophysics is a branch of science that uses the methods of physics to study biological processes. Physics uses mathematical laws to explain the natural world, and it can be applied to biological organisms and systems to gain insight into their workings (Biology Dictionary).
    4. Biophysics is the field that applies the theories and methods of physics to understand how biological systems work (Biophysical Society).
    5. Biophysics is an interdisciplinary science that applies approaches and methods traditionally used in physics to study biological phenomena (Encyclopaedia Britannica).
    6. Biophysics is the study of physical processes occurring in living organisms.
    7. Biophysics is the branch of biology that applies the methods of physics to the study of biological structures and processes (Thesaurus.com).
    8. Biophysics is the science of the application of the laws of physics to biological phenomena (Oxford Languages).

8. **Read the text "WHAT IS BIOPHYSICS". Fill in the blanks (A-H) with the appropriate headings (1-9) from the list below.**
    1. ***Biophysics: The Bridging Science***
    2. Molecules in Motion
    3. Computer Modelling
    4. Imaging
    5. Data Analysis and Structure
    6. Medical Applications
    7. Ecosystems

8. What Do Biophysicists Do?

WHAT IS BIOPHYSICS?



Taken from https://www.biophysics.org/what-is-biophysicsbrochure.pdf

Biophysics is the field that applies the theories and methods of physics to understand how biological systems work.

Biophysics has been critical to understanding the mechanics of how the molecules of life are made, how different parts of a cell move and function, and how complex systems in our bodies – the brain, circulation, immune system, and others – work. Biophysics is a vibrant scientific field where scientists from many fields including math, chemistry, physics, engineering, pharmacology, and materials sciences, use their skills to explore and develop new tools for understanding how biology – all life – works.

A. ***1. Biophysics: The Bridging Science***

(1) Physical scientists use mathematics to explain what happens in nature. Life scientists want to understand how biological systems work. These systems include molecules, cells, organisms, and ecosystems that are very complex. Biological research in the 21st century involves experiments that produce huge amounts of data. How can biologists even begin to understand this data or predict how these systems might work?

This is where biophysicists come in. Biophysicists are uniquely trained in the quantitative sciences of physics, math, and chemistry and can tackle a wide array of topics, ranging from how nerve cells communicate, to how plant cells capture light and transform it into energy, to how changes in the DNA of healthy cells can trigger their transformation into cancer cells, to so many other biological problems.

B.

(2) Biophysicists work to develop methods to overcome disease, eradicate global hunger, produce renewable energy sources, design cutting-edge technologies, and

solve countless scientific mysteries. In short, biophysicists are at the forefront of solving age-old human problems as well as problems of the future.

C.

(3) The structure of DNA was solved in 1953 using biophysics, and this discovery was critical to showing how DNA is like a blueprint for life.

Now we can read the sequences of DNA from thousands of humans and all varieties of living organisms. Biophysical techniques are also essential to the analysis of these vast quantities of data.

D.

(4) Biophysicists develop and use computer modelling methods to see and manipulate the shapes and structures of proteins, viruses, and other complex molecules, crucial information needed to develop new drug targets or understand how proteins mutate and cause tumours to grow.

E.

(5) Biophysicists study how hormones move around the cell, and how cells communicate with each other. Using fluorescent tags, biophysicists have been able to make cells glow like a firefly under a microscope and learn about the cell's sophisticated internal transit system.

F.

(6) Biophysicists have developed sophisticated diagnostic imaging techniques including MRIs, CT scans, and PET scans. Biophysics continues to be essential to the development of even safer, faster, and more precise technology to improve medical imaging and teach us more about the body's inner workings.

G.

(7) Environmental biophysics measures and models all aspects of the environment from the stratosphere to deep ocean vents. Environmental biophysicists research the diverse microbial communities that inhabit every niche of this planet, they track pollutants across the atmosphere and are finding ways to turn algae into biofuels.

H.

(8) Biophysics has been essential to the development of many life-saving treatments and devices including kidney dialysis, radiation therapy, cardiac defibrillators, pacemakers, and artificial heart valves.

Taken from https://www.biophysics.org/what-is-biophysics

9. Look through the list of words and phrases and check if you know their Ukrainian equivalents. Take turns to ask each other. Use the MINI-DICTIONARY section in Unit 2 if necessary.

biophysics	uniquely trained
biological system	be able to tackle
apply	a wide array of topics
molecule	range from … to
plant cell	renewable energy source
circulation	cutting-edge technology
immune system	a blueprint for life
biofuel	life-saving treatment
vibrant scientific field	fluorescent tag
pharmacology	internal transit system
materials sciences	environmental biophysics
physical scientists	stratosphere
life scientists	deep ocean vent
ecosystem	microbial community
kidney dialysis	cardiac defibrillators
radiation therapy	pacemaker

USE OF ENGLISH

10. Find in the text synonyms to the following words.

1. comprise (para. 1);
2. complicated (para. 1);
3. defeat (para. 2);
4. prototype (para. 3);
5. fundamental (para. 3);
6. modify (para. 4);
7. carrying (para. 5);
8. accurate (para.6);
9. occupy (para. 7);
10. fabricated (para. 8).

11. Fill in the gaps with the words from exercise 9. You may need to change the form of some words.

1. The whole endeavour will be both scientifically and financially ***complicated***.
2. When samples used are not representative of the real world, it becomes very difficult to reach ________ conclusions.
3. SpaceX is constructing ________ in Boca Chica, Texas, of its heavy-lift Starship spacecraft and Super Heavy rocket.
4. This _______ assumption had yet to be tested in an experimental study.
5. Fake and out-of-context screenshots, videos, and images Misinformation doesn't have to be entirely _______.
6. The symptoms may _______ not only a diversity of physical ailments but intellectual disturbances of the most terrible nature.

12. Explain the meaning of the words and phrases:

to apply, biological system, complex systems in our bodies, vibrant scientific field, materials sciences, molecules, cells, organisms, ecosystems, quantitative sciences, tackle a wide array of topics, plant cells capture light, DNA, overcome disease, renewable energy sources, cutting-edge technologies, blueprint for life, fluorescent tag, cell transit system.

13. Fill in the blanks in the sentences below with the correct word / phrase from the box. Use each word only once.

Achievements, proven, functional structures, nanostructures, advantage, ~~DNA~~, viable alternative, membranes, dimensional, tight control, enabled, simplicity

Over the last decade, functionally designed **(1)** ***DNA*** nanostructures applied to lipid membranes prompted important **(2)** ________ in the fields of biophysics and synthetic biology. Taking **(3)** _________ of the universal rules for self-assembly of complementary oligonucleotides, DNA has **(4)** ________ to be an extremely versatile biocompatible building material on the nanoscale.

Taken from ***https://info.gbiosciences.com/blog/the-basics-of-genomic-dna-extraction***

The possibility to integrate functional groups into oligonucleotides **(5)** _________ a widespread usage of DNA as a / an **(6)** _________ to proteins concerning functional activity on membranes. Hybrid DNA-lipid **(7)** _________ can mediate events such as vesicle docking and fusion, or selective partitioning of molecules into phase-separated **(8)** __________. Moreover, the major benefit of DNA structural constructs is the reproducibility and **(9)** _________ of their design. DNA nanotechnology can produce **(10)** _________ with subnanometer precision and allow for a **(11)** _________ over their biochemical functionality, e.g., interaction partners. DNA-based membrane nanopores and origami structures able to assemble into two-**(12)** __________ networks on top of lipid bilayers are recent examples of the manifold of complex devices that can be achieved.

Taken from https://pubmed.ncbi.nlm.nih.gov/27119630/

14. Match the words (1-10) with their definitions (a-j).

1. biological system	a) the application of concepts and methods of biology to solve real-world problems related to life sciences or the application thereof, using engineering's own analytical and synthetic methodologies
2. biological organization	b) a technique used for determining the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of incident X-rays to diffract into many specific directions
3. biochemistry	c) manipulation of matter on an atomic, molecular, and supramolecular scale
4. physical chemistry	d) refers to applications of quantum mechanics and theoretical chemistry to biological objects and problems
5. nanotechnology	e) the study of chemical processes within and relating to living organisms
6. bio-engineering	f) a complex network of biologically relevant entities
7. computational biology	g) a molecule that carries the genetic instructions used in the growth, development, functioning and reproduction of all known living organisms and many viruses
8.deoxyribonucleic acid	h) involves the development and application of data-analytical and theoretical methods, mathematical modelling and computational simulation techniques to the study of biological, behavioural, and social systems
9. X-ray crystallography	**i)** the hierarchy of complex biological structures and systems that define life using a reductionist approach
. 10. quantum biology	**j)** the study of macroscopic, atomic, subatomic, and particulate phenomena in chemical systems

15. Choose and underline the acceptable word.

1. Modern biophysics combines state-of-the-art physical ***measurements*** **/ features** with computational models to understand the detailed physical mechanisms underlying the behaviour of complex biological systems.
2. Biophysics is a growing enterprise worldwide, driven primarily by the widespread realization of the major contributions made to biological **study / science** by a combination of truly state-of-the-art physical measurements with modern molecular biology.
3. The field occupies a unique and central **position / state** at the intersection of the biological, chemical, physical, and computational sciences.
4. Biophysics is intrinsically **interdisciplinary / dual**.
5. Biophysics takes a quantitative, physical, non-phenomenological approach to biology that is firmly **rooted / traced** in the principles of condensed-phase physics and physical chemistry.
6. Biophysicists are driven primarily by their curiosity about how biological systems work at the molecular **organisms / level**.
7. Biophysicists as a group most often develop novel, sophisticated experimental **methods / ways** that reveal molecular-level details with unprecedented clarity.
8. The state of the art in x-ray crystallography, solution phase and solid-state NMR, atomic force microscopy, single-molecule methods, EPR, and fluorescence microscopy continue to evolve in ways that better elucidate biological **structure / features** and function.
9. In parallel, biophysicists are developing powerful new computational tools based on firmly established physical **reasoning / principles** that are sufficiently accurate to greatly enhance insights from experiments.
10. Just as the tools of molecular biology gradually become **useful / useless** to biophysicists, over time the new tools developed by biophysicists find widespread use among all biological scientists.

16. There is an extra word in each line. Find it and write in the space provided.

1. An important contribution of biophysicists to ~~***new***~~ modern biology	***new***
2. is the perspective that in biological processes can be understood	
3. from the level interactions between and within the constituent	
4. molecules. Therefore, the behaviours from of biological systems	
5. can be predicted from physical and principles. A biological problem	
6. that has been mostly tackled by biophysicists is in protein folding,	
7. by which a nascent polypeptide chain coming away off the ribosome	
8. finds its but unique structure in its native environment. The broad	
9. outlines of how the protein avoids the vast number of alternative and	
10. conformations and quickly finds its native in the structure are now	
11. clear. Some may go as far as claiming the problem is being solved.	

17. Fill in the gaps with the words derived from the words in bold.

For decades, protein engineers (**1)** ***have endeavoured*** (**ENDEAVOUR**) to reengineer existing proteins for novel applications. Overall, protein folds and gross functions can (**2) _______** (**TRANSFER**) from one protein to another by transplanting large blocks of sequence. However, predictably fine-tuning function (**3) _______** (**REMAIN**) a challenge. One approach (**4) _______** (**BE**) to use the sequences of protein families to identify amino acid positions that (5**) _______** (**CHANGE**) during the evolution of functional variation. The rationale is that these no conserved positions could (**6) ________** (**MUTATE**) to predictably fine-tune function. Evolutionary approaches to protein (**7) ________ (DESIGN)** have had some success, but the engineered proteins seldom replicate the functional (**8) ________ (PERFORM)** of natural proteins. This Biophysical Perspective reviews several (**9) ________ (COMPLEX)** that (**10) ________ (REVEAL)** by evolutionary and experimental studies of protein function.

Taken from *https://pubmed.ncbi.nlm.nih.gov/27410729/*

18. Put the verbs in brackets into the correct form (infinitive, -ed or -ing).

The origin of biophysics antedates the division of natural sciences into **(1)** ***separate*** (**SEPARATE)** disciplines. Bioluminescence must be **(2) _______** (**CONSIDER**) among the most ancient objects of biophysical exploration because the emission of light by **(3) _______** (**LIVE**) organisms has long stimulated the curiosity of natural philosophers. Perhaps the first scientific investigation of animal luminescence was that of Athanasius Kircher, a 17th-century German Jesuit priest, who **(4) _______** (**DEVOTE**) two chapters of his book *Ars Magna Lucis et Umbrae* to bioluminescence. In the midst of his more scientific observations, Kircher found time **(5) _______** (**EXPOSE**) as a fallacy the notion that an extract made from fireflies could **(6) _______** (**USE**) to lighthouses.

Taken from *https://www.britannica.com/science/biophysics*

19. Match the words (1-10) with their definitions (a-j).

1. natural science	a) The shortening and thickening of a functioning muscle or muscle fiber
2. bioluminescence	b) Important or essential as resolving a crisis
3. emission of light	c) To gain ascendancy through strength or superiority
4. propagate	d) The conversion of the chemical energy of a battery into electrical energy
5. discharge	e) To transmit (something, such as sound or light) through a medium
6. prevail	f) Radiation in the visible wavelength range due to photons emitted by discrete semiconductor devices

7. crucial	g) The emission of light from living organisms (such as fireflies, dinoflagellates, and bacteria) as the result of internal, typically oxidative chemical reactions
8. contraction	h) Any of the sciences (such as physics, chemistry, or biology) that deal with matter, energy, and their interrelations and transformations or with objectively measurable phenomena

20. Fill in the gaps with the correct prepositions from the box.

between, by, from, in, into, out, to, with

1. The origin of biophysics antedates the division of natural sciences ***<u>into</u>*** separate disciplines.
2. Bioluminescence must be considered among the most ancient objects of biophysical exploration because the emission of light _______ living organisms has long stimulated the curiosity of natural philosophers.
3. Perhaps the first scientific investigation of animal luminescence was Athanasius Kircher, a 17th-century German Jesuit priest, who devoted two chapters of his book Ars Magna Lucis et Umbrae ______ bioluminescence.
4. In the midst of his more scientific observations, Kircher found time to expose as a fallacy the notion that an extract made ________ fireflies could be used to light houses.
5. The relation ________ electricity and biology became a subject of speculation in the 17th century and one of intense exploration in the 18th and 19th.
6. Sir Isaac Newton in the Principia (1687) wrote of "a certain most subtle spirit which pervades and lies hid ________ all gross bodies."
7. Man's fascination ________ animal electricity is illustrated in a letter written by John Walsh in 1773 to the American inventor and statesman Benjamin Franklin.

8. Walsh wrote the details of his discovery of the electrical nature of the discharge ________ the torpedo or electric ray.
9. Typical of the unity of science that then prevailed were the advances sometimes made by either ________ professors of physics who were interested in biological phenomena or professors of anatomy, a subject that at that time included physiology.
10. Abbé Giovanni Beccaria, professor of physics in Turin and Italy's leading student of electricity in the mid-18th century, carried ________ experiments on the electrical stimulation of muscles.

21. Match numbers (1−5) with letters (a−e) to make up the sentences.

1. The biophysical approach is unified by a consideration of biological	a. from a purely descriptive science into a discipline increasingly devoted to understanding the nature of the prime movers of biological events.
2. Biophysics may be thought of as the central circle in a two-dimensional array	b. great impetus from the biophysical and biochemical discoveries of the 20th century.
3. Relations with chemistry are mediated through biochemistry and	c. chemistry; those with physiology, through neurophysiology and sensory physiology.
4. Biology, which may be viewed as a general subject pervading biophysical study, is evolving	d. of overlapping circles, which include physics, chemistry, physiology, and general biology.
5. The evolution of biology in these directions has received	e. problems in the light of physical concepts, so biophysics is, perforce, interdisciplinary.

22. Correct the grammatical mistakes. If the sentence is correct, put a '∨'.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

1. A deep understanding of the physical principles governing biological effects ***is*** ~~***being***~~ the proper end of biophysics.
2. The content and methods of biophysics are illustrated by examine several notable contributions to science.
3. The development of instruments for biological purposes is an important aspect of a new area – applying biophysics.
4. Biomedical instrumentation is probably the more widely used in hospitals.
5. Applied biophysics are important in the field of therapeutic radiology.
6. As aids in diagnosis and patient care, computers are of increasing importance.
7. Automation of the chemical analyses routinely carried out inside hospitals will soon be a reality.
8. The opportunities for the applications of biophysics seem limitless because the lengthy delay between the development of a research instrument and its application means.
9. From mammals to microorganisms such as bacteria or micro-algae, cells from the basis of all life.
10. Cells consist of a multitude of different building blocks which studied in biophysics.
11. As a multidisciplinary field of research, biophysics combines biological, physical and chemistry questions.
12. All cells are surrounded by a protective envelope, the membrane, which separate the inside from the outside of the cell.
13. At the Max Planck Institute of Biophysics, we are mainly interested on protein molecules that are located in this membrane.
14. Being a connection between the cell interior and the fluid surrounding the cells, the membrane proteins control the transport of substances and the transfer of information within a living organism.

15. Membrane proteins playing an important role when investigating body functions and diseases, or developing new drugs.

23. Choose the correct answer.

1. Physics provides the fundamental theories for ___*A*____ biomolecules.

A understanding **B** understand **C** understood **D is** understood

2. Electron transfer within protein matrices, ________ drives respiration and photosynthesis, and can only be understood with the help of quantum mechanics.

A who **B** which **C** where **D** -

3. An electron can hop from one position ______ another within a protein matrix only when the energy levels before and after the hop are equal.

A on **B** in **C** to **D** at

4. A lot of the powerful tools for investigating biomolecules _______ by physicists.

A initiated **B** were initiating **C** initiated **D** were initiated

5. X-rays were discovered by Wilhelm Röntgen and ______ diffraction by crystals was first demonstrated by Max von Laue.

A their **B** these **C** those **D** what

6. The subsequent mathematical formulation of the diffraction pattern ______ the Braggs, father and son, ushered in the new field of X-ray crystallography.

A on **B** by **C** at **D** about

7. Many computational techniques that are now widely ______ for modelling biomolecular systems also have their origins in physics.

A were used **B** has used **C** used **D** using

8. However, _______ the significant barrier to the transition from physics to biology, intellectually it is probably still far easier than the transition in the opposite direction.

A nevertheless **B** opposite **C** in spite **D** despite

9. A great biophysicists contribution to biology is the perspective that biological processes _______ understood from the interactions within the constituent molecules.

A can be **B** must be **C** can **D** should

10. The broad outlines of how the protein ______ the vast number of alternative

conformations and quickly finds its native structure are now clear.

A is avoiding **B** avoids **C** avoid **D** avoided

TRANSLATION

24. Choose the correct option.

1. Вченими було описано понад 2 мільйони наявних видів організмів. Багато ще залишається відкрити.

A. More than 2 million existing species of organisms have been described. Many more remain to be discovered.

B. More than 2 million existing species of organisms were described. Many more remain to be discovered.

C. More than 2 million existing species of organisms have been described. Many remain to be discovered.

2. Практично нескінченна кількість варіацій життя є результатом еволюційного процесу.

A. The virtually infinite variations in life are the result of the evolutionary process.

B. The virtually infinite variations in life are the fruit of the evolutionary process.

C. The virtually infinite variations in life are the fruit of the evolution process.

3. Усі живі істоти пов'язані між собою походженням від спільних предків.

A. All living creatures are related by descent from common predecessors.

B. All living creatures are related by descent from common ancestors.

C. All living creatures related by descent from common ancestors.

4. Люди та інші ссавці походять від землерийок, схожих на ссавців, які жили понад 150 мільйонів років тому.

A. Humans and other mammals descend from shrew creatures that lived more than 150 million years ago.

B. Humans and other mammal descend from shrew-like creatures that lived more than 150 million years ago.

C. Humans and other mammals descend from shrew-like creatures that lived more than 150 million years ago.

5. Родоводи організмів змінюються з покоління на покоління. Різноманіття виникає через те, що лінії від спільних предків розходяться з часом.

A. Lineages of organisms change through generations. Diversity arises because the lineages that descend from common ancestors diverge through time.

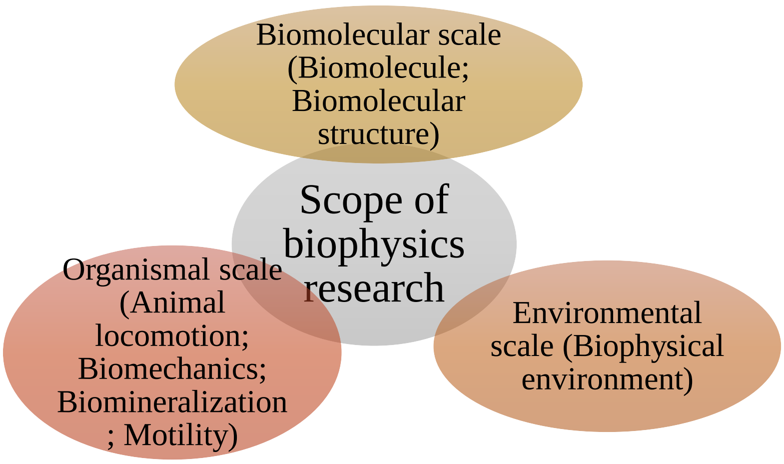
B. Lineages of organisms change through generation. Diversity arises because the lineages that descend from common ancestors diverge through time.

C. Lineages of organisms change through generations. Diversity arises due to the lineages that descend from common ancestors diverge through time.

Taken from **https://www.britannica.com/science/evolution-scientific-theory#ref176461**

SPEAKING

25. The main areas of research in modern biophysics are shown in the following diagram. In small groups / pairs arrange these areas in order of their importance. Make a list and explain your choice.



26. Below you can find different biophysical techniques. Read their definitions and in pairs choose ten of the most useful / important for biophysical research.

Biophotonics – a combination of biology and photonics, with photonics being the science and technology of generation, manipulation, and detection of photons, quantum units of light. Biophotonics can also be described as the "development and application of optical techniques, particularly imaging, to the study of biological molecules, cells and tissue". One of the main benefits of using optical techniques which make up biophotonics is that they preserve the integrity of the biological cells being examined.

Calcium imaging – various optical techniques for recording the location and concentration of calcium. Typically, this is done in cell and tissue samples using either genetically encoded or chemically derived fluorescent calcium-indicating dyes.

Calorimetry – Isothermal Titration Calorimetry (ITC) – measures the heat effects caused by interactions.

Chromatography – various techniques from this field are used for the purification and analysis of biological molecules.

Computational chemistry – use of numerical methods to probe the structure and dynamical equilibrium in biological systems.

Dual Polarisation Interferometry – an analytical technique used to measure the real-time conformation and activity of a wide range of biomolecules and their interactions.

Electrophysiology – studies electrical properties of cell membranes and provide functional data, often related to systematic changes in structure.

Patch clamping – provides temporal and electrical information of a cell or a portion of the membrane. Typically, this provides data on electrogenic processes, such as ion channel or transporter activity.

Electron microscopy – used to gain high-resolution images of subcellular structures and proteins.

Force spectroscopy – probes the mechanical properties of individual molecules or macromolecular assemblies using small flexible cantilevers, focused laser light, or magnetic fields.

Gel electrophoresis – determines the mass, the charge and the interactions of biological molecules.

Imaging – scientific imaging of biological materials, usually by some form of microscopy, or sometimes indirectly such as in x-ray crystallography or by computer imaging; at a wide range of magnifications to see macromolecules, cells, tissues, or organisms.

Mass spectrometry – a technique that gives the molecular mass with great accuracy.

Microscale Thermophoresis (MST) – method to measure binding affinities, enzymatic activities, changes in molecule conformation and changes in size, charge or hydration entropy.

Microscopy – used in many ways, for example, to enable the use of laser instruments for scanning and transmission.

Optical tweezers and Magnetic tweezers – allow for the manipulation of single molecules, providing information about DNA and its interaction with proteins and molecular motors, such as Helicase and RNA polymerase.

NMR spectroscopy – provides information about the exact structure of biological molecules, as well as on dynamics.

Single-molecule spectroscopy – a general term applied to a class of techniques that are sensitive enough to detect single molecules and often incorporates fluorescence detection.

Small-angle X-ray scattering (SAXS) – a technique that gives a rough low-resolution molecular structure.

Spectrophotometry – measurement of the transmission of light through different solutions or substances at different wavelengths of light.

Spectroscopy and Circular dichroism – method for detecting chiral groups in molecules, especially to determine the secondary structure of proteins.

Ultracentrifugation – gives information on the shape and mass of molecules.

X-ray crystallography – method to determine the exact structure of molecules with atomic resolution.

27. There are many unresolved problems in biophysics. Some of them are listed below. Discuss in pairs / small groups what might be the way to solve them. Compare your ideas with the whole group. What pair / group was the most creative? Use the following phrases to express your opinion.

Giving your opinion	
In my opinion / view ...	Nobody will deny that ...
If you ask me ...	The way / As I see it...
As far as I can see / I'm concerned ...	Let me put it this / another way ...
It seems to me that ...	The point I'm trying to make is ...
I have the / a feeling that ...	Personally (speaking) I think ...
I think / feel / reckon / believe ...	I'm absolutely convinced that ...
If you want my opinion ...	My view / point of view is that ...
You can take it from me that ...	The way I look at / see it is this...
First of all / To start with I'd like to point out ...	What I actually meant was ... It's a fact that ...

Understanding intrinsically disordered proteins (IDP): It should be stressed that IDPs are different from normal proteins, and their very existence has challenged our understanding of protein structure and folding landscape theories. They don't have a structure on their own, the physics behind IDPs is rather different. Also, studying IDPs is more difficult, both experimentally (solubility issues) and computationally (too many conformations to sample).

DNA condensation: how an extended DNA coil packs into a nice toroidal structure (polymer collapse). Gene therapy has gained prominence in treating some types of cancers and hereditary diseases. We haven't yet identified a safe and successful delivery vehicle. The use of biocompatible polymers or peptides needs a thorough understanding of how the forces between a carrier and DNA can be regulated. With the advent of single-molecule techniques, this field has made a lot of progress.

Protein-lipid interactions and membrane dynamics: we know a fair amount about membrane structure, but we are still trying to understand membrane dynamics, how the bilayer is regulated, and how proteins are involved in regulating bilayers. Understanding membrane dynamics will help in understanding cellular signalling, and provide a different perspective on exocytosis and secretory pathways.

Ion channels**:** understanding what ion channels do and how they do it. How can we modulate their function, channel gating and trafficking? Ion channels play such an important role in regulating cellular functions, yet, very little is known of them at the molecular level.

Mitochondrial bioenergetics: many mitochondrial metabolites regulate/activate tumour-progressive genes. In addition, reactive oxygen species are produced by the respiratory chain. Mitochondrial mutations have also been reported in tumours. Thus, understanding mitochondrial proteins/ion channels/membrane/signalling, is all equally important.

LISTENING

28. Before listening about biochemists' and biophysicists' careers, check if you know the meaning of the following words.

medical cure, resilient, wheat, nerve cell communication, proteins, fluorescent microscopes, ensure, accuracy, precision, perseverance, essential, keep regular hours, pharmaceutical manufacturing, entry-level positions, bachelor's degree, master's degree.

Scan the QR code. Listen to the information about biochemists' and biophysicists' careers and choose the correct answer.

1. What do biochemists and biophysicists study?

a) medical history;

b) ***<u>living things;</u>***

c) grow of wheat.

2. What advanced technologies are NOT used in biophysics?

a) lasers;

b) fluorescent microscopes;

c) frequency counter.

3. Biophysicists are responsible for…

a) writing research papers;

b) sponsoring the teams;

c) making technical recommendations.

4. Biophysicists should have good skills in …

a) mathematics;

b) law and justice;

c) team building.

5. What education is needed for experienced biophysicists?

a) bachelor's degree;

b) master's degree;

c) PhD.

29. Listen to the information in 'Biochemists and Biophysicists Career Video' for the second time and complete the following sentences.

1. Biochemists and biophysicists study ***living things*** and the processes that make them grow, change and die.
2. Advanced technology is often used on the job, _______ lasers and fluorescent microscopes.
3. Conducting scientific experiments takes ________ ___ _________, as well as strong maths skills, good judgment, and perseverance.
4. Biochemists and biophysicists typically work in laboratories to _______ ________ and in offices to analyse the results.
5. Employers include research and development companies, higher education, and ________ manufacturing.

30. Before watching the instructions about the work of a spectrophotometer, check if you know the meaning of the following words.

source of light, beam, strikes, the diffraction grating, prism, wavelength, rotate, exit slit, sample, transmittance, absorbance, detector, measurement, convert, digital display.

31. Scan the QR code. Watch the video 'How does a spectrophotometer work?' with the instructions and answer the following questions.

1. What is the source of light for the spectrophotometer?
2. What is used as a prism?
3. How many wavelengths reach the exit slit at a time?

4. What is measured in the sample?
5. What device shows the information on a display?

32. Watch the video 'How does a spectrophotometer work?' for the second time and write the instructions for a spectrophotometer. Study the following tips for writing instructions.

Checklist for Writing Instructions

1. Use short sentences and short paragraphs.
2. Arrange your points in logical order.
3. Make your statements specific.
4. Use the imperative mood.
5. Put the most important item in each sentence at the beginning.
6. Say one thing in each sentence.
7. Choose your words carefully, avoiding jargon and technical terms if you can.
8. Give an example or an analogy, if you think a statement may puzzle a reader.
9. Check your completed draft for the logic of the presentation.
10. Don't omit steps or take shortcuts.

(Adapted from Writing with Precision by Jefferson D. Bates. Penguin, 2000)

WRITING

33. Write a short essay (100-120 words) about career prospects in biophysics. You may use the next questions as a plan. Scan the QR code below for some extra materials to help you with ideas (https://www.biophysics.org/Portals/0/BPSAssets/Brochures/Documents/WhatisBiophysics.pdf).

- What does a biophysicist do?
- Where does a biophysicist work?
- What is the job demand for biophysicists?
- Biophysics jobs description.

- What are the education requirements to become a biophysicist?
- What kind of societies and professional organizations do biophysicists have?

34. Study the project "*Growing Plants in Space*" launched by NACA. In groups prepare a plan of your own project concerning growing plants for astronauts. What does the project involve?

***Taken from** https://kissflow.com/project/steps-to-create-successful-project-plan/*

The first growth test of crops in the Advanced Plant Habitat aboard the International Space Station yielded great results. Arabidopsis seeds - small flowering plants related to cabbage and mustard - grew for about six weeks, and dwarf wheat for five weeks.

Taken from NASA ***https://www.nasa.gov/content/growing-plants-in-space***

Growing Plants in Space

As humans explore space, we will want to bring plants for both aesthetic and practical reasons. We already know from our pioneering astronauts that fresh flowers and gardens on the International Space Station create a beautiful atmosphere and let us take a little piece of Earth with us on our journeys. They're good for our psychological well-being on Earth and in space. They also will be critical for keeping astronauts healthy on long-duration missions.

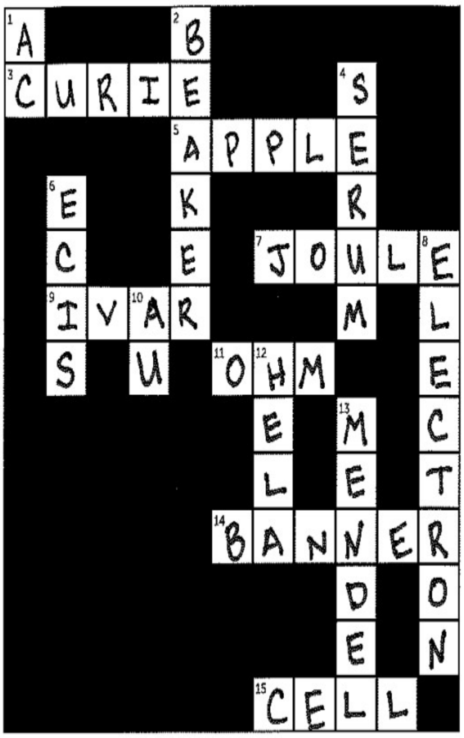
A lack of vitamin C was all it took to give sailors scurvy and vitamin deficiencies can cause several other health problems. Simply packing some multivitamins will not be enough to keep astronauts healthy as they explore deep space. They will need fresh produce.

Right now, on the space station, astronauts receive regular shipments of a wide variety of freeze-dried and prepackaged meals to cover their dietary needs – resupply missions keep them freshly stocked. When crews venture further into space, travelling for months or years without resupply shipments, the vitamins in prepackaged form break down over time, which presents a problem for astronaut health.

NASA is looking at ways to provide astronauts with nutrients in a long-lasting, easily absorbed form – freshly grown fresh fruits and vegetables. The challenge is how to do that in a closed environment without sunlight or Earth's gravity.

Taken from https://www.nasa.gov/content/growing-plants-in-space

35. Work in small groups. Study the example of Applied Biophysics Crossword and make up a crossword for your group-mates using vocabulary from this Unit.



ACROSS

3 Polish born scientist with 2 Nobel Prizes. Physics, Chemistry.
5 Newton's famous fruit.
7 Unit of energy.
9 1973 Nobel Prize in Physics recipient from Norway ____ Giaever.
11 Unit of Resistance.
14 Fictional scientist who experimented with Gamma Radiation
15 Term first used by R. Hooke in 1665.

DOWN

1 Current type used in ECIS systems.
2 Assistant of Dr. Bunsen Honeydew.
4 Cell Food
6 First Cell Based Impedance System invented by Giaever, Keese.
8 Nucleus componant
10 Soft,biologically inert metal element used in ECIS Arrays.
12 Famous immortalized cell line developed in 1951.
13 Famous "Pea Farmer" in 1856.

Taken from https://www.biophysics.com/public/pdf/ComicCrosswordApr2020Answers.pdf

EXTRA READING

36. Read Text A "Bioluminescence" (see EXTRA READING section to Unit 2) and decide whether the statements from the text are true (T) or false (F).

1.	2.	3.	4.	5.

1. Bioluminescence could be seen in tropical seas only.
2. Bioluminescence is the result of chemical energy conversion.
3. The animals can use light to survive and recognize other living creatures.
4. Some fireflies rely on light colour and specific recognition codes to search for and attract other species.
5. Some fishes possess a large nasal rod with a luminous organ.

37. Read Text A "Bioluminescence" (see EXTRA READING section to Unit 2) and find the words to which the following ones are synonyms. Choose any three words and use them in the sentences of your own:

1	determine (para. 1)	***derive***
2	glistening, glowing (para. 1)	…
3	take place (para. 1)	…
4	retreat, exit (para. 2)	…
5	unquestionable (para. 2)	…
6	beam, radiate (par. 3)	…
7	feedback, reply (par. 3)	…
8	count on, trust (par. 3)	…
9	own (par. 4)	…

10	strength, energy (par. 4)	…
11	determine, figure out (par. 5)	…
12	satisfactory (par. 5)	…

38. Read Text B "Molecular biology" (see EXTRA READING to Unit 2) and decide whether the statements are true (T) or false (F).

1.	2.	3.	4.	5.

1. Molecular biology studies the DNA.
2. The DNA contains a different sequence of several hundreds of 20 amino acids.
3. Genes could be compared to language sentences with the sequence of letters and words.
4. Humans' cytochrome differs from horses by 21 additional amino acids.
5. All possible tests have been done but no one has given evidence to prove the evolution theory yet.

39. Read Text B "Molecular biology" (see EXTRA READING section to Unit 2) and find the words to which the following ones are the synonyms. Choose any three words and use them in the sentences of your own:

1	confirmation (para. 1)	***evidence***
2	heritage (para. 1)	…
3	collected (para. 2)	…
4	contain (para. 2)	…
5	explain, expose (para. 3)	…
6	different, another (par. 3)	…

7	progression, arrangement (par. 4)	…
8	descendant (par. 4)	…
9	sovereign (par. 5)	…
10	closeness, resemblance (par. 6)	…
11	inquiring, inspecting (par. 6)	…
12	complete, execute (par. 7)	…

PROBLEM-SOLVING

40. Do the quiz (see the PROBLEM-SOLVING section in Unit 2).

Unit 3. OPTICS AND HOLOGRAPHY

"Beauty is a question of optics. All sight is illusion." **Joyce Carol Oates**

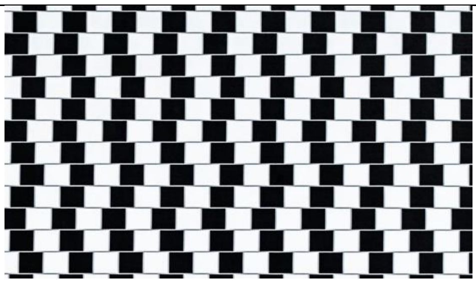
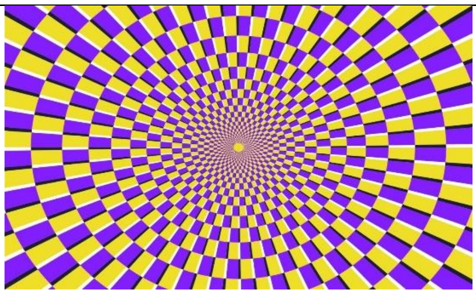
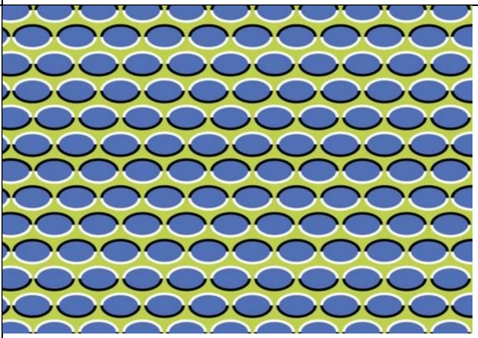
***Taken from** https://www.optics4kids.org/what-is-optics/basics*

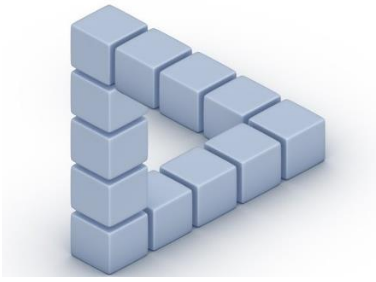
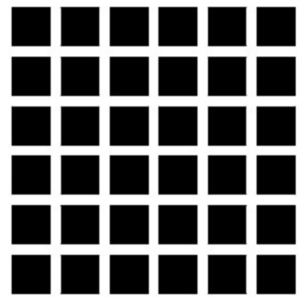
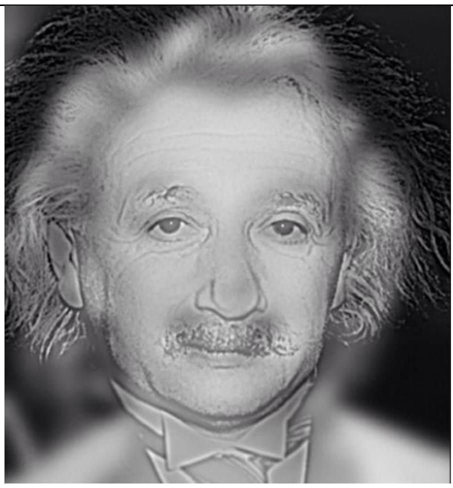
WARM-UP

1. **List the words which are associated with *Optics* and *Holography*. Compare your choices in pairs. What is the link between these two terms?**
2. **Discuss the following quotations in pairs, choose the one you agree with and explain why. Use the phrases:** *obviously ..., to my mind ..., in my opinion ..., I strongly believe that ..., I doubt ..., as far as I understand ..., etc.*

1. "The boundary between science fiction and social reality is an optical illusion." *Donna J. Haraway*
2. "Music is the arithmetic of sounds as optics is the geometry of light." *Claude Debussy*
3. "Our separation from each other is an optical illusion." *Albert Einstein*
4. "Beauty is the result of clarity and system and not of optical illusion." *Henry van de Velde*
5. "Pictures, propagated by motion along the fibres of the optic nerves in the brain, are the cause of vision." *Isaac Newton*
6. "There are optical illusions in time as well as space." *Marcel Proust*
7. "Optimism and pessimism are mere matters of optics, of how you look at things, and that can change from day to day, or with a new prescription for your glasses - or with a new set of ideological filters." *George Weigel*
8. "Time is an optical illusion - never quite as solid or strong as we think it is." *Jodi Picoult*

3. **Have a look at some of the popular optical illusions (<u>click here to see more illusions</u>). Match the pictures with their names and descriptions.**

1.		a)	**Rubin's Vase** This is a classic optical illusion example! Some people see a vase, others see two faces.
2.		b)	**Ripple Effect.** When you take a peek at this optical illusion, you may see a ripple go through the image. This is because of the seamless pattern of circles.
3.		c)	**Walking a Fine Line.** Feast your eyes on this optical illusion! These lines seem skewed but they are actually parallel.
4.		d)	**Spiralling Downwards.** If you stare at the centre of this optical illusion, your eyes will trick you into thinking the area around it is moving!
5.		e)	**It's All About Perspective.** For this fun photo trick, the photographer put the dinosaur near the camera, set a self-timer, and then ran to a further distance to pull this optical illusion!

6.		f)	**Marilyn Einstein.** Did you know this optical illusion can help optometrists diagnose eye problems? If you can see Marilyn Monroe at a comfortable reading distance, you may need glasses!
7.		g)	**Penrose Triangle.** This optical illusion is also called the "Impossible Triangle" because it can be depicted in a perspective drawing, but cannot exist as a solid object.
8.		h)	**Troxler Effect.** If you stare at the X for about 20 seconds, the Cheshire Cat will completely disappear. The popular literature character fades away because of the eye's tendency to prioritize. If you focus on the X, all other distractions in your peripheral vision will fade away.
9.		i)	**Hermann Grid.** This phenomenon is the result of a neural process called lateral inhibition. Basically, when a lot of light is let into a neuron in your eyes (like the white lines), the neurons can't process all of it, so black dots appear.

4. Think about the practical applications of the illusions listed above in daily life.

READING

5. **Underline the stressed syllable in each word as in the example. Practise reading:**

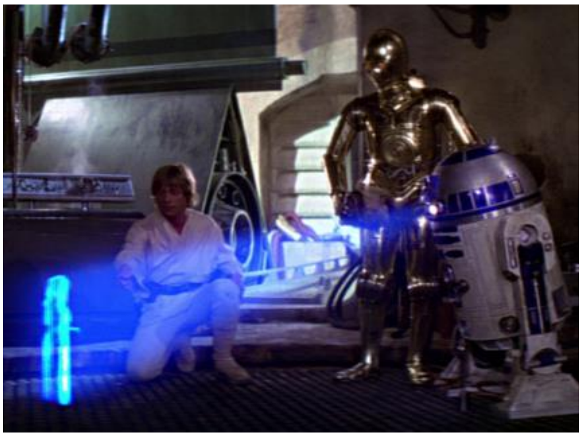
fascinated, projection, holographic, misrepresentations, originated, dimensional, immediately, precisely, visualisation, perspective, sophisticated, applications, manufacturers, comprehend, noticeable.

6. **Read the text "The Essence of Holography" and choose the appropriate heading (A-E) to fill in the gaps (1-5).**

A. Holography and entertainment
B. Background of holography
C. Holography matters
D. Life-changing practical applications
E. Working principle of Holography

The Essence of Holography

1. _______. We seem to be fascinated by holograms or at least the promise of what they can do. Think about the famous Princess Leia projection in Star Wars; holographic fashion shows in New York, Hamburg and Beijing; the massive success of synthetic pop star Hatsune Miku in Japan.



Taken from https://urbanactioncinema.com/?p=2881

Technically, all of these are misrepresentations of holography – either special cinematic effects, video projections onto water and smoke, or a hi-tech version of an old Victorian stage trick called Pepper's Ghost.

2. ______ . The word hologram originated from a combination of two Greek words: "holos," which means "whole," and "gramma," which means "message," which come together to produce a complete message or a whole picture. A hologram, unlike

ordinary photography, is a three-dimensional image. Holograms are real-world virtual three-dimensional pictures generated by the interference of light beams that reflect real-world physical objects. More precisely, holography is the study of generating and then recording light patterns caused by the interaction of two light beams. The reference beam is immediately imprinted on the recording medium, whereas the object beam interacts with the recording material via being transmitted through or reflected off the topic of investigation.

3. ______. There are several types of holographic methods that use light, often in the form of lasers, to produce various effects. An angled mirror divides a laser beam into two distinct beams to produce these holograms. The holographic picture seems three-dimensional because it provides the observer with depth perception clues. It is due to reconstructing the whole light field, which is dispersed by the item. The observer may wander around examining the thing from multiple angles, maybe even peering behind an object in front of them. On the other hand, a two-dimensional snapshot can only display the scene from the perspective chosen during the recording. There are computer-generated holograms for augmented reality glasses and actual holograms for optical displays.

4.______. Holography practical use has primarily been used for replicas of artists and actors performing on stage or appearing in product advertisements. However, it is the next step beyond an ordinary film, and its three-dimensionality opens up whole new applications, including building simulated environments for real-time training, education, and visualisation; package or credit card security, medical imaging for a more precise image, and detail-oriented mapping, surface metrology, microscopy, and data storage. Because of the exact quality of the holographic picture, it has also been used to capture and display valuable things that are typically not on exhibit to the public. Many healthcare systems employ sophisticated imaging equipment, such as magnetic resonance imaging and ultrasound scans, to create complex data.

5. ________

Holography graphically displays information, and data is known as data visualisation. It employs visual components such as charts, maps, and graphs to help users comprehend data trends, patterns, and outliers.

Taken from https://news.sky.com/story/whitney-to-elvis-holograms-that-have-brought-stars-back-to-life-11942830

In recent years, one of the most noticeable applications of this technology has been its usage in concerts. Stars from the past can be revived to perform again and even live on stage with current performers. These displays can also be utilised for live shows when the musicians are not physically present but transmit their pictures. Holographic display tables that enable real-time multiplayer games are already being explored in the gaming industry. Manufacturers are also incorporating this technology into the next generation of smartphone screens, allowing portable 3D gaming.

Holographic technology's practical uses are numerous, they have exceeded the entertainment sector and have become a standard part of our daily lives.

Adapted from the article "Holography and its applications for industry 4.0: An overview"

7. Read the text 'The Essence of Holography' and answer the following questions:

1) What is the origin of the word "hologram"?
2) What is the basic working principle of holography?
3) Why is this technology so valuable for humanity?
4) In which spheres are holographic technologies used?
5) How is it used in entertainment?

8. **Look through the list of words and phrases and check if you know their Ukrainian equivalents. Use the MINI-DICTIONARY section to Unit 3 if necessary.**

fascinated	imprinted
misrepresentation	transmitted
three-dimensional	distinct
interference	perception
light beam	dispersed
reflect	augmented reality
precisely	replica
interaction	incorporating
reference beam	exceed
capture	peering
investigation	sophisticated

USE OF ENGLISH

9. **Explain the meaning of the words and phrases taken from the text:**

special cinematic effects, video projections, ordinary photography, three-dimensional image, light patterns, recording medium, depth perception clues, light field, examining the thing from multiple angles, product advertisements, detail-oriented mapping, surface metrology, multiplayer games.

10. **Cross the odd word out, explain why. The first is done for you.**

a) beneficial, worthy, valuable, ~~comprehensive~~;

b) demonstrate, exhibit, conceal, display;

c) understand, perceive, comprehend, comprise;

d) dissipate, distort, scatter, disperse;

e) erroneous, accurate, precise, rigorous.

11. Select definitions (a–j) from the list to match the key terms (1-10).

1.	light beam	**a)**	coloured band produced when a beam of light passes through a prism
2.	spectrum	**b)**	change in the form of an electrical signal or sound wave during processing
3.	reflection	**c)**	the phenomenon in which the phase velocity of a wave depends on its frequency
4.	distortion	**d)**	permitting light to pass through, but not transparent
5.	diffraction	**e)**	a narrow concentration of light energy emitted from a small source
6.	dispersion	**f)**	not letting light through
7.	transparent	**g)**	the bouncing back of a ray of light, sound, or heat when the ray hits a surface that it does not go through
8.	opaque	**h)**	the combination of two or more waves that results in a single wave
9.	translucent	**i)**	a change in the direction of a wave when the wave finds an obstacle or an edge, such as an opening
10.	interference	**j)**	allowing light to pass through

12. Complete the sentences using the words from Exercise 11. Then, use the remaining words to make up sentences of your own. Use each word once. The first is done for you.

1. Due to the ***diffraction*** of water droplets in the cloud, we can often observe pastel shades of blue, pink, purple, and green.
2. Specular _____ is what a mirror does or what we see on perfectly flat water or any other surface that reflects incoming parallel light rays in such a way that they all stay parallel.

3. One of the best examples of the _____ of light is demonstrated by the light reflected from a film of oil floating on water. Another example is the soap bubble that reflects a variety of beautiful colours when illuminated by natural or artificial light sources.
4. As the full _____ of visible light travels through a prism, the wavelengths separate into the colours of the rainbow because each colour is a different wavelength.
5. Prism is an optical element which is _____with flat, polished surfaces that refract light.

13. Match the words / phrases in the left-hand column with ones in the right-hand column to make collocations from the text. Use each word / phrase only once. Translate the collocations into Ukrainian.

1.	hi-tech	***a)***	pictures
2.	real-world virtual three-dimensional	***b)***	angles
3.	real-world physical	***c)***	sector
4.	transmitted through or reflected off the topic of	***d)***	version
5.	wander around examining the thing from multiple	***e)***	games
6.	building simulated	***f)***	objects
7.	real-time multiplayer	***g)***	screens
8.	entertainment	***h)***	environments
9.	interference of light	***i)***	beams
10.	next generation of smartphone	***j)***	investigation

14. Fill in the correct synonyms from the list below. Use each phrase only once.

proportional, ~~variety~~, reconstruct, comprised, superimposing

1. The ability to use electrons to transport optical phase information potentially opens up a ***variety*** of applications in electron microscopy and beyond. (**multiplicity)**
2. A simple hologram can be made by **____** two plane waves from the same light source on a light recording medium such as a photographic emulsion. **(overlapping)**
3. An amplitude modulation hologram is the one where the amplitude of light diffracted by the hologram is **____** to the intensity of the recorded light. **(corresponding)**
4. Three-dimensional images called holograms were first shown in the early 1960s and required laser light to **____** the image. **(reproduce**)
5. Researchers at the Digital Nature Group have found a way to create three-dimensional, interactive holograms **____** of tiny points of light plasma called voxels. **(consisting)**

15. Fill in the correct antonyms from the list below. Use each phrase only once.

united, ~~encrypted~~, combination, prove, specific

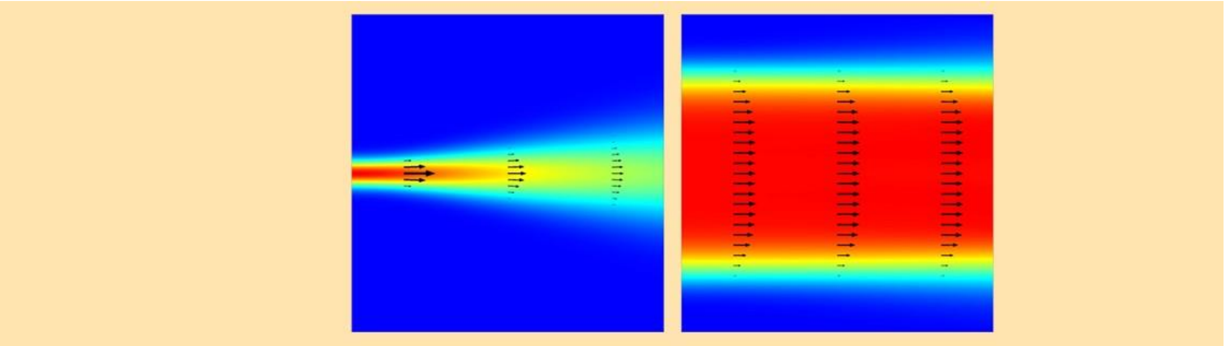
1. Holographic recording using ***encrypted*** reference waves enables secure storage of information. (**decoded**)
2. **Many smart cards today are equipped with holograms** because they **____** to be particularly forgery-proof. **(contradict)**
3. The hologram is produced on a smart card using a **____** of **laser technology and multilayer foils**. **(demarcation)**
4. A photograph can be viewed in a wide range of lighting conditions, whereas holograms can only be viewed with very **____** forms of illumination. **(common)**
5. To record a hologram of a complex object, a laser beam is first **____** into two beams of light. **(united)**

16. Fill in the word derived from the word in bold.

Information storage

We now generate huge amounts of data. Digital storage capacity increases (and becomes cheaper) every year and we have an insatiable desire to **(1)** ***store*** **(STORAGE)** our data and keep it for a lifetime. Just think about your own computer and the hundreds of gigabytes of information it can store, from family photos to videos and documents. Now consider your storage disc – and everyone else's – being **(2)** ____ **(CORRUPTION)** and the vast losses involved. All very timely, given the recent WannaCry ransomware attack, which affected 150 countries.

A holographic image is **(3)** ____ **(STUNNING)** realistic because the recording process stores all of the information about the light reflected from the recorded subject. That is a massive amount of information.



Taken from *https://www.comsol.fr/blogs/simulating-holographic-data-storage-in-comsol-multiphysics/*

But holograms don't have to record information about a visual object – they can also record pure data, pages and pages of it. This means that holograms can, potentially, store **(4)** ____ **(THINK)** amounts of information.

If you make an optical hologram of a page of information and then smash it, for example, you can **(5)** ____ **(RECONSTRUCTION)** it from any of the pieces. This makes holographic data storage extremely **(6)** ____ **(RELY)**. Unlike CDs and DVDs, which store their data on the disc's surface, holograms store data in three dimensions and those pages can overlap in the storage space. **(7)** ____ **(RESEARCH)** have been suggesting the **(8)** ____ **(POSSIBLE)** of holographic data storage for over 50 years and it looks like they are getting closer to a **(9)** ____ **(USE)** system. Indeed, as computing begins to be based on light (photons), rather than electricity (electrons), holographic storage could one day be the storage **(10) ____ (SOLVE)** of choice.

17. Fill in the table with the words derived from the given ones.

Verb	Noun	Adjective	Adverb
energize	***energy***	***energetic, energizing***	***energetically***
interfere	…	…	interferingly
…	comprehension	…	comprehendingly
apply	…	applicable	…
…	reflection	…	X
examine	examination	…	X
…	…	emitted	X
…	illumination	…	illuminatingly

18. Fill in the gaps with the correct preposition from the box.

on, of (2), in (2), from, out, by (2), for, with

1. Geographic intelligence is an essential part ***of*** military strategy and fully dimensional holographic images are being used to improve reconnaissance.
2. Holography could also revolutionise medicine, as a tool ___ visualising patient data while training students and surgeons.
3. Artists became involved ___ holography almost as soon as it became a practical optical process.
4. We think of holography as something that stands ___ and pokes us in the eye, but a great deal of work and research is actually quietly taking place in labs and studios around the world.

5. Electronic information is used to display a flat image ___ a computer screen, but it can also be used to produce full-colour, computer-generated 3D holographic images.
6. An important characteristic of light waves is their ability, ___ certain circumstances, to interfere ___ one another.
7. The dynamic interplay of colours derives ___ the simultaneous reflection of light from both the inside and outside surfaces of the bubble.
8. Thomas Young was an early 19th-century physicist who demonstrated interference ___ showing that light is a wave phenomenon, and he also postulated that different colours of light were made from waves with different lengths.
9. "The Double-Slit experiment", originally used sunlight that had first been diffracted ___ a single slit as a light source, but we will describe the experiment using coherent red laser light.
10. Sir Isaac Newton, the famous 17th-century mathematician and physicist, was one ___ the first scientists to study interference phenomena.

19. Study information in the table below. Then fill in the correct phrasal verb.

Give off	emit, to produce heat, light, a smell, or a gas	випромінювати, викидати (в атмосферу)
Derive from	to come or develop from something	випливати з (про інформацію і т.д.)
Come up with	think of something such as idea	спасти на думку
Make up	create, invent	придумати, вигадати
Open up	to show something that was hidden or not previously known	відкрити щось нове

1. A team out of South Korea ***made up*** the world's first hologram capable of being viewed simultaneously in 360 degrees by using a series of multi-coloured, high-powered lasers and a high-speed rotating mirror display.

Taken from https://studiousguy.com/light-interference-examples/

2. Much information about practical applications of holography can be ___ the scientific journals.
3. Scientists have recently ___ the new idea of holography application in medicine.
4. This dynamic interplay of colours ___ the simultaneous reflection of light from both the inside and outside surfaces of the bubble.
5. Close examination of the visible-light spectrum from our Sun and other stars ___ a pattern of dark lines, called absorption lines.
6. This micro-sized light has three LED bulbs that ___ red, white UV, and flashing lights for any unforeseen situation.
7. Scientists around the world have ___ inventive ways to use lasers, modern digital processors, and motion sensing technologies to create several different types of holograms which could change the way we consume and interact with media.
8. In our laboratory at the university, we ___ a new overhead projector that can display holographic images.
9. The closer investigation of the case can provide important scientific clues that ___ hidden properties of objects throughout the universe.
10. The lamp in this room ___ soft yellow light comfortable for working.

20. Match the left part (1-6) with the right part (a-f) to complete the sentences (pay attention to the dependent prepositions).

1.	Isaac Newton's experiment in 1665 showed that a prism bends visible light and that each colour refracts at a slightly different angle depending	**a)**	onto a specially designed high-speed reciprocating screen.
2.	The key to this The Double Slit Experiment is the mutual coherence	**b)**	for laser illumination to view the hologram, and to make it.
3.	A digital image is printed onto a suitable mask or film and illuminated F	**c)**	from the inner and outer surface combine, they will interfere.
4.	In common practice, major image quality compromises are made to remove the need	**d)**	between the light diffracted from the two slits at the barrier.
5.	Hundreds of digital cross-sections of an image are projected synchronously	**e)**	on the wavelength of the colour.
6.	When the light waves reflected	**f)**	by a suitable source to reconstruct the wavefront of interest.

21. Put the verbs in brackets into the correct form.

Holograms **(1)** ***have provided*** (**PROVIDE**) great fun to people of all ages for over half a century, after the invention of the laser in the 1960s **(2)** ___ **(ENABLE)** the creation of these interesting images. In fact, the technology behind this form of imaging **(3)** ___ **(BE)** in development for almost double this timeframe, originating with research into X-ray crystallography conducted in the 1920s. But it was not until more recently that holograms began to emerge in formats that are more recognisable to the modern eye. The concept of a hologram is relatively simple — it is simply a representation of a seemingly three-dimensional image on a two-dimensional surface, **(4)** ___ **(ACHIEVE)** using a dot matrix system, electron-beam lithography, or, more recently, computer imaging. The hologram itself is a set of nanostructures represented on a flat surface. These nanostructures then **(5) ___ (REFRACT)** light in a specific way to project an optical illusion based on the pattern.

22. Choose and underline the acceptable word.

Prism Experiment

What is the significance of the dispersion of light into its spectrum of colours?

Newton was the first to **(1) *conduct* / carry** this experiment on passing light through a prism. He let sunlight pass through the prism expecting to see the white light on the screen placed on the other side but instead, he saw the spectrum of light after **(2) diffraction** / **dispersion**. He had a small hunch regarding the significance here but decided to do something else here to **(3) confirm** / **rehearse** it. By **(4) controlling / manipulating** the size of the inlet, he allowed only one colour (therefore only one wavelength of light) of light to pass **(5) through / by** the prism. Obviously, the ray of light was **(6) transferred / refracted** and didn't undergo any further dispersion. Therefore, he **(7) realized / disproved** that different colours of the spectrum of light **(8) magnify / bend** differently as they have different **(9) wavelengths /bandwidth**. He made the observation that violet bent the most and red the least because of their shorter and longer wavelengths **(10) applicably / respectively**.

23. Fill in the blanks with the words from the box. Use each phrase only once.

~~complex~~, tilt, advantage, reassure, visible, en masse, counterfeit, transmission, forge

Holograms are **(1) *complex*** optical devices and difficult to make, which gives them an incredible **(2) ____** in the commercial security market. You probably have a security hologram in your pocket at the moment. That small silver rectangle of a dove on your credit card is a white-light, mirror-backed, **(3)** ____ hologram. It displays a three-dimensional image which is **(4)** ____ as you move from side to side, and changes colour as you **(5)** ____ your card up and down. It's very easy to manufacture **(6)** ____ – but also extremely difficult to **(7)** ____. Banknotes have also championed the use of secure holograms. The reflective strip on the new UK polymer £5 banknote **(8)** ____ an image of Big Ben and uses holography to produce a set of changing colours as you tilt the note, as well as a 3D image of the coronation crown, which can be seen "floating" above it.

If you want to be sure you are drinking the "real deal", winemakers also add holographic labels to their bottles to **(9)** ____ buyers that they contain vintage wine rather than a less delicious **(10)** ____.

24. Choose the correct answer.

1. Holography ___***A***____ a three-dimensional image out of lasers, more accuaratethan photographically caught two-dimensional images.

A is making **B** has made **C** made **D** is made

2. The holograph technique _______ the wave aspect of the light source to create three-dimensional images.

A is used **B** uses **C** using **D** has been used

3. Tree-dimentional images made by holographic technique are capable _______ slight movement and change as another light source is drawn over it.

A at **B** in **C** about **D** of

4. The process of creating holograms is quite similar to photography but requires purer light sources instead of ordinary light, _______ is incoherent.

A which **B** who **C** what **D** this

5. In order to attain more accuracy, laser beams are used in the photographic plate _______ the reference beam.

A for **B** as **C** from **D** in

6. The reference beam or reference wave saves the patterns of the beam on the film placed on the photographic plate, with the process _______ done completely under the lack of any other light.

A was **B** has been **C** being **D** been

7. The photographic plate then requires a second beam _______ the film, with both beams meeting at a wide-angle on the plate, creating an interference pattern.

A create **B** to create **C** have created **D** to have created

8. The resulting image is a hologram that ________ be printed on a suitable medium.

A must **B** should **C** need **D** can

9. Viewers can _______ use light on the same and see the desired reconstructed wave.

A further **B** farther **C** later **D** longer

10. In holography, a wavefront is first recorded and then re-constructed _______ 3D-images.

A generating **B** generated **C** to generate **D** generate

Taken from https://kidadl.com/facts/revolutionary-holography-facts-for-every-photography-enthusiast

TRANSLATION

25. Choose the correct option.

1. Денніс Габор створив принцип голографії в 1947 році і за це отримав Нобелівську премію з фізики в 1971 році.

   A. Dennis Gabor has created the principle of holography in 1947, for which he also received the Nobel Prize in Physics in 1971.

   B. Dennis Gabor created the principle of holography in 1947, for which he also got the Nobel Prize in Physics in 1971.

   C. Dennis Gabor had created the principle of holography in 1947, for which he also had got the Nobel Prize in Physics in 1971.

2. Голографію було створено шляхом запису хвильового фронту та його реконструкції для отримання зображення.

   A. Holography was created by recording a wavefront and reconstructing it to produce an image.

B. Holography has been created by recording a front of a wave and reconstructing it to produce an image.

C. Holography created recording a wavefront and reconstructing it to produce an image.

3. Голограма складається з багатовимірних відтінків всіх кольорів, що створюють тривимірний ефект на предметах завдяки своєму блиску, що змінює колір під різними кутами.

   A. The hologram consists of multi-dimensional shades of all colours, creating a 3D effect on things due to its colour-changing shine at different angles.

   B. The hologram is consisting of multi-dimensional shades of all colours, to create a 3D effect on things with its colour-changing shine at different angles.

   C. The hologram consists of multi-dimensional shades of all colours, creating a 3D effect on things in spite of its colour-changing shine at different angles.

4. Найпоширенішим застосуванням голографії в наш час є створення тривимірних зображень предметів, які зараз широко використовуються в освіті.

   A. The creation of three-dimensional images of things is the most common application of holography at present, which is now widely used in education.

   B. The most common application of holography at present is the creation of three-dimensional images of things, which are now widely used in education.

   C. The most common application of three-dimensional images at present is the creation holography of things, which are now widely used in education.

5. Етикетки на продукті, створеному за допомогою голографічної технології, містять ту саму технологію та також дозволяють зберігати незліченну кількість інформації.

   A. The labels on the product created with holographic technology contain the same technology and also allow you to save countless amounts of information.

   B. Labels on a product created with holographic technology encounter the same technology and also allow you to store countless amounts of information.

C. Labels on a product created with holographic technology contain the same technology and also allow you to store countless amounts of information.

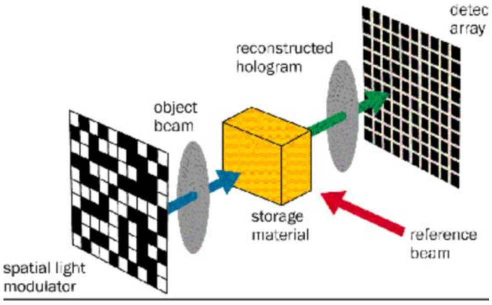
SPEAKING

A. Look at the pictures that demonstrate practical applications of holography. Match the pictures with descriptions.

1

https://modernbattlespace.com/

3



https://physicsworld.com/a/optical-data-storage-enters-a-new-dimension/

2

https://www.dicardiology.com/article/first-4d-hologram-guided-structural-heart-procedure-performed-laa-occlusion

4

https://www.alamy.com/stock-photo/five-pound-note.html?sortBy=relevant

A data storage

B military mapping

C hologram guided surgery

D data security, anti-counterfeit

B. Which of these applications do you consider to be the most important for society? Which one is the least important? Prove your idea.

26. Read the short abstract about the use of holography in classrooms and discuss the questions below:

1. Would you like to be taught by a holographic teacher? Why/Why not?
2. What are the benefits and negative aspects of a holographic teacher compared to the real one? Use the following phrases to express your opinion.

Talking about advantages	*Talking about disadvantages*
The advantage of…	*The disadvantage of…*
The argument in favour of…	*The argument against…*
The benefit of …	*The drawback/downside of…*
The positive aspect of …	*The negative aspect of*

Cast your mind back to the turn of the last century. Experts predicted that by now classrooms would no longer feature human teachers, and holographic virtual entities would deliver lessons instead. This certainly hasn't happened. The closest we have come is group video chat via apps like Zoom or Google Meet. But this doesn't mean holograms aren't part of our lives – they're just marketed differently. For the past 20 years, researchers and companies have progressed with a vision of "mixed reality", where the physical and digital blend together to create digitally enhanced experiences. Initially limited to research labs and prototypes, we have seen a major increase in the use of mixed-reality technology in recent years. And it's of particular use in classroom settings.

Adapted from https://theconversation.com/holographic-teachers-were-supposed-to-be-part-of-our-future-what-happened-108500

27. **Look through the short abstract about holograms use in education. Discuss with your groupmates some other ideas on how to use holography in education.**

https://elearningindustry.com/advancements-in-virtual-reality-emerging-tools-in-education

Hologram technology has the potential to significantly improve the educational environment. It has the potential to enable interactive digital instruction in educational institutions. By merging digital and real-world data, this technology can potentially provide mixed reality. To better grasp complicated subjects, students can explore and interact with holographic pictures. In a history class, for example, students can view individual atomic particles and their behaviour, or they might examine the remains of old cultural structures.

LISTENING

28. **Before watching the video 'Holograms: What is possible in the near future?', check if you know the meaning of the following words and phrases:**

digitally rendered projections, hold in store, transparent, naked eye, intermediaries, resurrected, underwhelming, carbon footprint, augmented reality goggles, gimmick

29. **Scan the QR code. Watch the video 'Holograms: What is possible in the near future?' and decide whether the statements from the text are true (*T*) or false (*F*).**

1.	2.	3.	4.	5.

1. Technically speaking, 2D projections onto a screen are not real holograms.
2. Special goggles are required to see the hologram.
3. Nowadays holograms are not used in communications because of technical difficulties.
4. Systems that work without the use of screens are already developed but they are not available for the general market due to their big size and high price.
5. Holographic communication is hardly possible in future.

30. Watch the video 'Holograms: What is possible in the near future?' for the second time and discuss the following questions in pairs.

1. Do you like the idea of using holograms in the circus? Why?
2. Would you like to have the possibility to use 3D holograms to telecommunicate with your friends or relatives?
3. What are the obstacles to using holography in telecommunication?
4. What kind of opportunities can holography open for us in future?
5. What kind of benefits can we get with the opportunity to have our 3D avatars?

31. Before watching the video "Hologram Security Sticker and Security Printing", discuss in a group the following questions:

1. Where are holographic images used, as security measures?
2. Do you consider holographic images to be trustworthy security measures?
3. What kind of equipment is needed to create a holographic image?
4. Is that easy to forge a document protected with a holographic image?
5. How do you think, holographic images will still be used in future?

32. Watch the video "Hologram Security Sticker and Security Printing" and choose the correct options:

1) Holography is used to fight ____.

a) counterfeiting

b) conspiracy

c) conferment

2) Hologram is a precise record of how light ____ of an object at different angles.

a) distorts

b) diffracts

c) refracts

3) It is harder to produce a hologram than a regular photograph due to the necessity to:

a) use special production technology

b) use specially educated specialists

c) to use expensive materials

4) Holograms have special engraving for the purpose of:

a) making them attractive

b) protecting them from harsh natural phenomena

c) protecting them from being forged

5) Officials can identify that a passport is forged, if they see that:

a) the hologram is not smooth on its surface

b) the ink changes colour

c) the ink's colour is too bright

6) The peculiarity of the latest US currency is that

a) it is printed in two and a half dimensions

b) the holographic image has a 3d effect

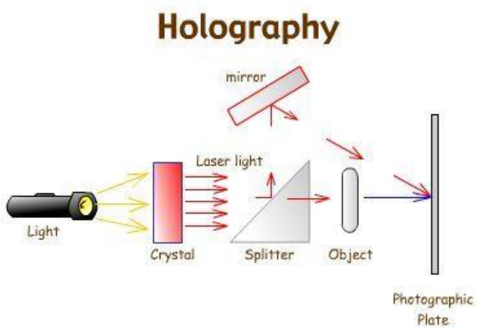
c) the image can shine

33. Watch the video "Hologram Security Sticker and Security Printing" for the second time and complete the sentences.

1. Documents like passports driver's licenses credit cards and cash are so hard to _____ these days.
2. Hologram is harder to produce than a regular photograph, you need lasers lenses and _____.
3. Holograms can still be copied given the _____.
4. Oftentimes governments can defeat people that try to modify passports illegally by printing them with _____ ink.
5. You can actually feel a bump with your finger that shifts colour depending on the _____.

WRITING

34. Examine the diagram demonstrating the working principle of holography. Present the summary, describing the stages of the process (use useful language box below).



Taken from https://www.pinterest.com/pin/400750066815432744/

Useful language

Referring to the images	Listing the stages
This stage is presented…	*Initially*
The image illustrates…	*At the first stage / first of all*
The diagram shows the stages of…	*Then / the next step is / after that*
Regarding the next image…	*Finally / eventually / the final step is*

35. Look through the list of predictions about the future of holography. Present and justify your opinion about each of the predictions.

Useful language	
Will definitely	*Definitely won't*
Might possibly	*Might not*
Is /are likely to	*Is / Are unlikely to*
Will probably	*Probably won't*

1. In future, students will probably have holographic teachers in the classes.
2. Today's video calls are likely to be replaced by holograms creating the opportunity to interact with friends, family, colleagues, etc. in a similar way to a physical conversation.
3. Holographic technology will also be useful to standardize industrial processes. Through the use of holograms, relocated factories will be able to speed up the process of manufacturing.
4. Vehicles will be equipped with a three-dimensional representation of GPS addresses or pedestrian identification.
5. 3D holographic displays will be affordable and will be inbuilt in all the gadgets.

36. In the box below you can see some areas in which holography is being developed. Choose 2 areas and write your predictions or innovative ideas. How do you expect holograms will be used in these areas in the future?

telecommunications	*industry*
culture	*health*
tourism	*transportation*
security	*education*

EXTRA READING

37. Read Text A 'Dennis Gabor, a Pioneer in Holography' (see the EXTRA READING section to Unit 3) and answer the following questions.

1. What inspired Dennis Gabour to have passion towards physics?
2. What was one of the first crucial inventions by Dennis Gabour?
3. What was the objective of carrying out the first experiments in holography?
4. What contribution to signal processing did Dennis Gabour make?
5. What other spheres of scientific interest except for holography did Dennis Gabour have?

39. Read Text A 'Dennis Gabor, a Pioneer in Holography' (see the EXTRA READING section to Unit 3) and decide whether the following statements are true (T) or false (F). Give your reasons.

1.	2.	3.	4.	5.

1. Denis Gabour decided to study engineering because it was prestigious.
2. The objective of his doctorate was to investigate high-speed, cathode ray oscillographs.
3. When Denis Gabour worked in England, he started conducting basic experiments in holography.
4. As a scientist, Gabour solely contributed to theoretical work for communications, plasmas, and magnetrons.
5. Dennis Gabour considered that social inventions are very important and shouldn't be neglected by inventors.

40. Read Text B 'Hologram Technology – Myths and Facts about it' (see the EXTRA READING section to Unit 3) and find the words to which the following ones (1-5) are the synonyms:

1.	accurate, exact (para. 1)	***precise***
2.	knowledge, understanding (para. 2)	**…**
3.	mainstream, banality (para. 3)	**…**
4.	inexpensive, reasonably priced (para. 3)	**…**
5.	misapprehension (para. 5)	**…**

41. Read Text B 'Hologram Technology – Myths and Facts about it' (see the EXTRA READING section to Unit 3) and decide whether the following statements are true (T) or false (F). Give your reasons.

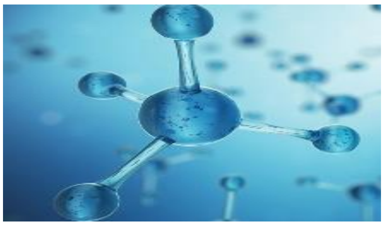
1.	**2.**	**3.**	**4.**	**5.**

1. Holograms are made using a special scanning technique.
2. Holograms are used by companies mostly to get customers acquainted with their products.
3. The prices for holographic displays have remained steady for the past few years.
4. It's impossible to create a hologram that would look like any other image.
5. Unique hologram on a flat surface is a real hologram.

PROBLEM-SOLVING

42. Do the quiz (see the PROBLEM-SOLVING section to Unit 3).

Unit 4. NANOTECHNOLOGIES



Taken from ***https://www.safetyandhealthmagazine.com/articles/16883-nanotechnology***

"Size does matter. Nano even better." ***Toba Betta***

WARM UP

1. List the words, which are associated with *Nanotechnologies*. Compare your answers in pairs.

2. In pairs, answer the following questions.

1. What is nanotechnology? What is nanoscience? What differs these two terms?
2. What are nanomaterials?
3. Can you think of any nanotechnological products? Are they available today?
4. How may nanotechnology affect the future?
5. What are nanoparticles? Are they safe or hazardous to our health, life, and environment? Give examples.

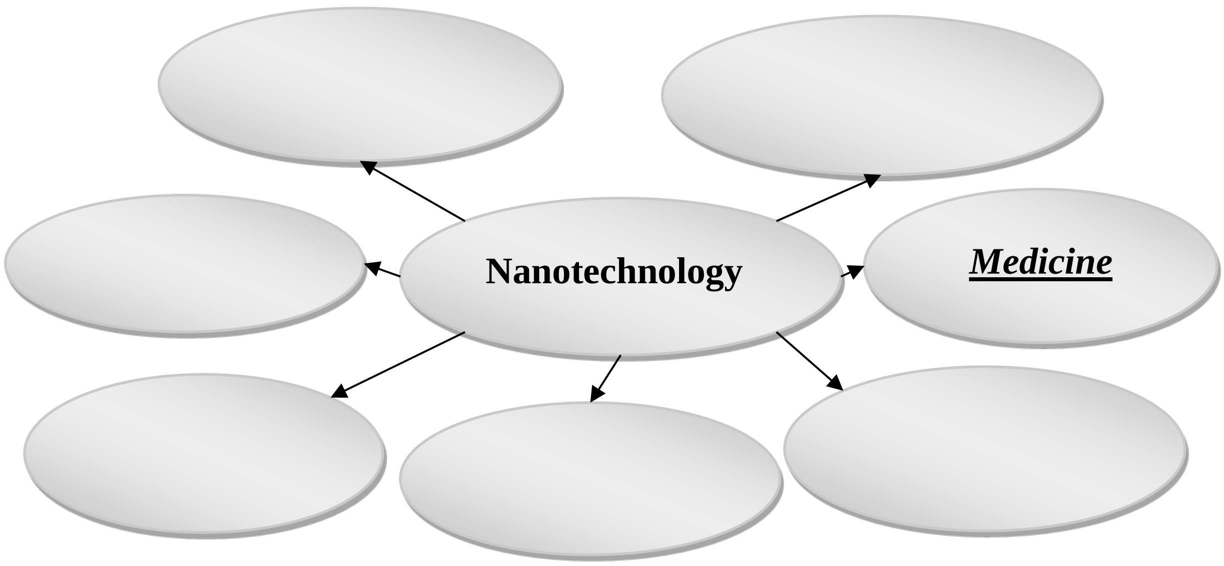
3. Discuss the following quotations in pairs, choose the one you agree with and explain why. Use the phrases: *If you ask me…, it seems to me that…, if you want my opinion…, nobody will deny that…, I'm absolutely convinced that…,* **etc.**

1. "Nanotechnology in medicine is going to have a major impact on the survival of the human race." *Bernard Marcus*
2. "The ultra-small has the potential to make enormous changes to our world." *Amanda Barnard*
3. "Nanotechnology will let us build computers that are incredibly powerful. We will have more power in the volume of a sugar cube than exist in the entire world today." *Ralph Merkle*
4. "By 2100, our destiny is to become like the gods we once worshipped and feared. But our tools will not be magic wands and potions but the science of computers,

nanotechnology, artificial intelligence, biotechnology, and most of all, the quantum theory." *Michio Kaku*

5. "Nanotechnology is an idea that most people simply didn't believe." *Ralph Merkle*

4. **Nanotechnologies are used in many spheres of science and manufacturing. In pairs, continue creating a mind map. Provide examples in each field.**



READING

5. **Underline the stressed syllable in each word as in the example. Practice reading:**

exos<u>ke</u>leton, advancements, harvesting, circular, encounters, nanoscale, applications, property, manipulating, micrometers, measurements, miniaturization, malleability, durable, robust, conductive, unpredictable, fabrication, descending.

6. **Read the text "Nanotechnology: Working Big, Thinking Small" and answer the following questions.**

1. What is nanotechnology? What does it study?
2. What is the measuring unit? Which size can be a nanoparticle?
3. How does the modern science classify different types of nanotechnology?

4. Which examples of nanotechnologies have been considered in the article?
5. Explain why nanotechnology is not just a process of miniaturization of what's happening at eye level.

7. **Read the text about nanotechnologies. Some paragraphs have been removed from the article. Choose from paragraphs A−C the one, which fits each gap (1−3).**

A. There are four major classifications that sort different types of nanotechnology happening now, arranged by the sequence in which they are developed or the mediums in which they work.

B. It's a standout marker for modern medicine that lays the groundwork for fighting against future pandemics, as stated in the journal.

C. When objects are manipulated on the nanometric scale, they can develop unusual properties – a change in color or increased malleability – that diverge from their presentation on the macroscopic scale.

NANOTECHNOLOGY: WORKING BIG, THINKING SMALL

"It's nanotech – you like it?" asks the billionaire superhero Iron Man, played by Robert Downey Jr., as a metallic liquid crawled to form an armored exoskeleton across his body, activated by the push of his chest plate.

Although this battle scene from Marvel's *Avengers: Infinity Wars* is simply fiction, a number of ambitious advancements in the field of nanotechnology can be equated to scenarios dreamt up only in sci-fi: injected sensors playing doctor inside of your body, self-healing materials, allowing planes to auto-repair mid-flight, a self-harvesting answer to climate change, where objects generate a circular economy of energy through movement.

In fact, you've probably already had a handful of encounters with commercialized atomic innovation, unwittingly. Nanotech, an industry exploring the qualities of matter on the nanoscale, has already premiered in everyday applications.

Nanotechnology studies unique property changes on the nanoscale by way of manipulating atoms and molecules. The intention is to then use these phenomena for use in the design, characterization, production and application for the benefit of materials, structures, devices and systems. This scale ranges from one basic unit, sized in likeness to atoms or molecules, to 100 nanometers. “Nanometer” translates to “one billionth of a meter.”

For reference, hair follicles or a sheet of paper are about 100,000 nanometers thick. Fingernails grow at the rate of one nanometer per second. Cells and bacteria are measured in micrometers – an entirely different scale for objects that outsize nanometric measurements.

It’s important to note that nanotechnology isn’t simply a miniaturization of what’s happening at eye level. **(1) ____.** A change in surface area can result in a change in physical, chemical, optical or mechanical makeup. Materials can become more durable, robust or conductive than their life-sized counterparts.

It’s not all science fiction and Marvel superhero suits, however. The stained glass windows decorating European medieval cathedrals and castles, for example, are some of the earliest known use cases of nanotechnology. Artisans discovered that they could create deep purples and rich reds by adding flecks of gold chloride or yellowish ambers from adding silver nitrate. As atomic particles rearrange, they reflect light differently.

Understanding these unpredictable properties that result from manipulating nanomaterials through innovative engineering and fabrication of macro-scale technologies is the task of researchers within this field. Essentially, nanotechnology can quite literally reshape the world as we know it.

(2) ____:

I. **Descending (top-down):** This approach minimizes structures and mechanisms currently in use to the nanoscale – ranging from atomic levels to 100 nanometers – to develop new technologies.

II. **Ascending (bottom-up):** Beginning with basic units of a nanometric structure, like an atom or molecule, nanotechnologists build from the ground up.

III. **Dry:** A type of nanotechnology classified by its work with inorganic materials, like metals and semiconductors that do not work with water.

IV. **Wet:** Takes a focus on processes that require water and biological systems that exist in an aqueous environment, such as cells.

The ability to tailor the core structures of materials at the nanoscale to achieve specific properties is at the heart of nanotechnology. Nanotechnologies are used in many spheres of our life nowadays. Among them are the following: sunscreen, clothing, furniture, adhesives, car paint, sports equipment, computers, food, medicine and fireproofing.

In its adolescence, the industry itself is still dreaming up what reengineering matter on the nanoscale can do for society.

Its direct hand in COVID-19 response is a top example of this. Tech innovation journal *Nano Today* attributed the 95-percent efficacy rate of two mRNA-based vaccines specifically to the use of nanocarriers, made up of lipid nanoparticles. **(3) ____.**

Nanotech is also showing promise in tackling climate change, by optimizing energy generation. On an individual scale, this can mean more storage embedded into electric car batteries or, on an industry scale, solar panels with higher conversion rates.

Taken from https://builtin.com/hardware/nanotechnology-examples

8. Look through the list of words and phrases and check if you know their Ukrainian equivalents. Take turns to ask each other. Use the MINI-DICTIONARY section of Unit 4 if necessary.

to crawl	flecks of gold chloride
an armored exoskeleton	arranged by the sequence
ambitious advancements	medium
equated	build from the ground up
dreamt up	semiconductors

auto-repair mid flight	an aqueous environment
a handful of encounters	to tailor the core structures
unwittingly	adhesives
a miniaturization	in its adolescence
increased malleability	direct hand in
durable	standout marker
robust	to tackle climate change
conductive	embedded into
life-sized counterparts	conversion rates
stained glass windows	to attribute

USE OF ENGLISH

9. Explain the meaning of the words and phrases taken from the text:

to auto-repair mid-flight, a self-harvesting answer to climate, a handful of encounters with commercialized atomic innovation, outsize nanometric measurements, in its adolescence, to tackle climate change.

10. Match the words/phrases (1-10) with their definitions (a-j). The first is done for you.

1.	exoskeleton ***(g)***	**a**	fixed into the surface of something
2.	embedded	**b**	the means of holding and protecting commodities for later use
3.	advancement	**c**	usually refers to structures with a length scale applicable to nanotechnology, usually cited as 1–100 nanometers (nm)
4.	nanoscale	**d**	transitional phase of growth

			and development between childhood and adulthood
5.	robust	**e**	an improvement relating to a particular activity or a rea of knowledge
6.	miniaturization	**f**	any of a class of crystalline solids intermediate in electrical conductivity between a conductor and an insulator
7.	atomic particle	**g**	a hard outer layer that covers, supports, and protects the body of an invertebrate animal
8.	semiconductor	**h**	strong and unlikely to break or fail
9.	adolescence	**g**	any of various self-contained units of matter or energy that are the fundamental constituents of all matter
10.	storage	**j**	the process of making something very small using modern technology

11. Complete the sentences using the words from Exercise 10. Then, use the remaining words to make up sentences of your own. Use each word once.

1. Unlike bulky ***exoskeleton*** technology, this low-profile clothing learns what the brain wants and corrects the body, instead of restraining it.
2. The ____ industry endured a great reversal last year.
3. The examination provides a good indication of the performance of energy ____ devices.
4. This shows just how small things at the ____ actually are.
5. The innocent belief that technological _________ involved a better future for humanity perished as a result.

12. Cross the odd word out and explain why. The first is done for you.

1) descend, go down, plummet, ~~***climb***~~***;***
2) embedded, installed, distorted, encapsulated;
3) armored, weak, invulnerable, shielded;

4) adhesive, loose, sticky, attaching;

5) standout, exceptional, plain, out of the ordinary.

13. Match the words / phrases in the left-hand column with ones in the right-hand column to make collocations from the text. Use each word/phrase only once. Translate the collocations into Ukrainian. The first one is done for you.

1.	takes a focus on ***(d)***	***a)***	levels
2.	its direct hand in covid-19	***b)***	structures
3.	tailor the core	***c)***	meter
4.	a change in surface	***d)***	processes
5.	one billionth of a(n)	***e)***	area
6.	simply a(n)	***f)***	applications
7.	ranging from atomic	***g)***	miniaturization
8.	in the field of	***h)***	response
9.	as atomic particles	***i)***	rearrange
10.	premiered in everyday	***j)***	nanotechnology

14. Expand the chunks by adding the words from the text. The first one is done for you.

1	understanding these	***unpredictable properties***
2	a miniaturization of what’s happening	climate change
3	promise in tackling	at eye level
4	reshape the world as	work with water

5	semiconductors that do not	we know it
6	they reflect light	counterparts
7	than their life-sized	differently
8	the qualities of matter	aqueous environment
9	exist in an	cathedrals and castles
10	decorating European medieval	on the nanoscale

15. Fill in the gaps with the appropriate words from the list below. Use each word/phrase only once.

Methods, productive, resources, hazardous, advancements, ~~nanoparticles~~, performance, synthesis, uncharged, synthesized.

The significance of (1) ***nanoparticles*** (NPs) in technological (2) _______ is due to their adaptable characteristics and enhanced (3) _______ over their parent material. They are frequently (4) ______ by reducing metal ions into (5) _______ nanoparticles using (6) ______ reducing agents.

However, there have been several initiatives in recent years to create green technology that uses natural(7) _______ instead of dangerous chemicals to produce nanoparticles. In green (8) _______, biological methods are used for the synthesis of NPs because biological methods are eco-friendly, clean, safe, cost-effective, uncomplicated, and highly (9) _______.

Numerous biological organisms, such as bacteria, actinomycetes, fungi, algae, yeast, and plants, are used for the green synthesis of NPs. Additionally, this paper will discuss nanoparticles, including their types, traits, synthesis (10) ________, applications, and prospects.

16. Fill in the table with the words derived from the given ones.

Verb	Noun	Adjective	Adverb
manipulate	***manipulator*** ***manipulation***	***manipulatory*** ***manipulatable***	***manipulatively***
…	…	…	advancingly
utilize	…	…	X
…	reference referrer	…	X
…	engineering	X	…
structuralize	…	…	…
…	…	…	indicatively
…	…	observant observative	X
suggest	…	…	…
…	process	…	X

17. Fill in the word derived from the word in bold.

From Heinz to Hershey, the household brands filling out your refrigerator drawers and kitchen cabinets likely ***(1) utilize*** **(UTILITY)** nanotechnology. *AZoNano* **(2)** ____ **(SUGGESTION)** that there are more than 400 global companies participating in novel, lab-to-table developments.

The field's leading actors — silver, titanium dioxide, silica, clay, gold and zinc – are the most commonly **(3)** ____ **(ENGINEERING)** elements used **(4)** ____ **(MANIPULATIVELY)** food products on the nanoscale, according to the Center for Food Safety.

Nano-iron **(5)** ____ **(OBSERVATION)** to treat water, breaking down organic pollutants and killing microbial pathogens during decontamination.

(6) ____ **(ADVANCINGLY)** in the texture of mayonnaise was made possible by nano-emulsion, where fatty, oil droplets overcrowd water and create pockets, changing the overall **(7)** ____ **(STRUCTURILIZE)**. Developers believe they can lower the condiment's fat percentage even more by injecting the fat molecules with water. Nestlé uses this **(8)** ____ (**PROCESSIVE)** to guarantee a uniform thawing experience across its frozen aisle products while Unilever reduced the fat percentage of its ice creams from 16 to 1 percent. Still, the use of taste, looks and texture are not the only **(9)** ____ **(INDICITAVELY)** of nanotech in the food sector.

18. Study information in the table below. Then fill in the correct phrasal verb. Use each word / phrase only once.

make up	to combine or to produce (a sum or whole)
break down	to divide into smaller parts
turn off	to stop the energy flow, to switch off
work out	to make a calculation
wear off	to fade away
try out	to test
take out	to remove from a place or thing
go over	to examine or look at something in a careful or detailed way
find out	discover
come across	to find unexpectedly

1. 10 chapters ***make up*** this volume.
2. The shine on the leather will ____ pretty quickly.
3. I've ____ the problem several times, but I can't think of a solution.

4. The scientists have ____ the sample from the device.
5. Our professor ____ the final project ____ into three separate parts.
6. We don't know how to use this. How can we ____?
7. We ____ this phenomenon while observing a completely different one.
8. The new setup is ready to be ____.
9. Is it possible to ____ the speed of light without fancy experiments?
10. The electricity should be completely ____ before commencing the experiment.

19. Match the idioms in the left-hand column with their definitions in the right-hand column. The first one is done for you.

1	It's not rocket science **(e)**	***a***	intuition, when something is not decided or felt by reasoning
2	To pull the plug	***b***	to become very angry
3	To blow a fuse	***c***	with all your energy and enthusiasm
4	Cutting edge	***d***	an extremely long time from now in the past or future
5	Well-oiled machine	***e***	when something is not very difficult to do or to understand
6	Lightyears away	***f***	the most modern stage of development in a particular type of work or activity
7	Full steam ahead	***g***	fully operating
8	Get down to business	***h***	to prevent an activity from continuing, especially by no longer giving money to support it
9	Up and running	***j***	an easily and effectively working system
10	Gut feeling	***k***	to start talking about the subject to be discussed

20. Fill in the gaps with the correct prepositions.

The super covalent bonds that stick nano-adhesives together are inspired **(1)** ***by*** the strongest model of van der Waals' forces – gecko toes. The billion-odd, tiny, elastic hairs known **(2)** ____ *setae* that line the reptilian's feet split into even smaller *spatulae* – about 200 nanometers in width and length – **(3)** ____ each end, aiding in the lizard's one-of-a-kind grip strength.

(4) ____ 2012, a group of scientists released an adhesive glue dubbed "Geckskin" that could secure 700 pounds **(5)** ____ a smooth surface utilizing carbon nanotubes. "Although carbon nanotubes are thousands **(6)** ____ times thinner than a human hair, they can be stronger than steel, lighter than plastic, more conductive **(7)** ____ copper for electricity and diamond for heat," writes Michael Berger, an editor **(8)** ____ online nanotechnology publication Nanowerk.

Thinner bonding lines give nano-fillers an advantage **(9)** ____ traditionally used micro-scale adhesives, which increase strength and durability. Molecular chains bonded **(10)** ____ a silicon, sulfur, carbon, and hydrogen cocktail created a nano-glue in 2007 that could not only withstand high temperatures but became stronger as the heat increased.

21. Choose and underline the acceptable word.

As demonstrated in a **(1)** ***decade*** **/ century**'s evolution of the smartphone, less is more in the world of computers. The aggressive focus on the efficiency of computer systems is **(2) ridden** / **driven** by a concept known as Moore's Law, **(3) established / found** in 1965, which **(4) foresaw / predicted** that the **(5) number / amount** of transistors packed into a circuit of a given size would be able to **(6) twice / double** every two years, per advancements. Thus far, American engineer and **(7) writer** / **author** of the principle, Gordon Moore, has been **(8) right / left**.

In 2021, IBM announced that it had successfully developed a silicon semiconductor **(9) sized / measured** at just two nanometers. It holds a 45 percent **(10) higher / bigger** performance rate than today's most advanced chips, more than **(11) thrice / triple** its size, a press release stated. For reference, this would allow

50 billion transistors to be crammed into a fingernail-sized chip.

22. Choose the correct answer.

1. A transformative approach ____ the treatment of many diseases.

   A ***to*** **B** for **C** on **D –**

2. The clinical capabilities of AAV vectors have prevailed ____ spite of difficulties.

   A at **B** in **C** for **D** on

3. Three plasmids are introduced ____ to producer cells.

   A for **B** in **C –** **D** on

4. Although insignificant differences ____ vector yields were found.

   A in **B** for **C** of **D** would

5. The previously discussed methods ____ the manual mixing.

   A ask for **B** require **C** command **D** request

6. Batch-to-batch variations may also ____ the production of nanogels.

   A impede **B** cripple **C** close **D** embarrass

7. In this work, we present a(n) ____ triple transfection method.

   A unorthodox **B** off the wall **C** novel **D** alternative

8. AAVs have shown ____ success in two recently approved products.

   A considerate **B** confident **C** considerable **D** considering

9. Microfluidics refers to the control and manipulation of fluid ____ at a microscopic scale.

   A surge **B** run **C** flow **D** course

10. In an effort to ____ the cytotoxicity due to its unwanted effects.

    A induce **B** reduce **C** produce **D** induct

23. Match numbers (1−6) with letters (a−f) to make up the sentences. The first one is done for you.

1	Some require patterning and some ***(b)***	***a***	are proposed in terms of materials selection, printing methods, or even the 4D printing approach.
2	Additive manufacturing technology	***b***	are based on full-area coating.
3	This selection must go hand in hand	***c***	to fabricate electronic devices.
4	While conventionally, 2D-printed electronic devices	***d***	with the adaptation of additive techniques.
5	The prospects for future research on 3D printed electronics with nanomaterials	***e***	also called 3D printing, is of great interest for electronics applications.
6	Printed electronics, in short, is an application of printing technologies	***f***	are manufactured mainly on flat substrates.

24. Choose the correct option.

1. Zhong Lin Wang, a professor at Georgia Institute of Technology, _____ nanogenerator technology since 2005.

   A has developed **B** developed **C** has been developing

2. Wang and his team _____ now how to harvest mechanical energy from organic and inorganic materials.

   A are exploring **B** have explored **C** explore

3. His work _____ that nanogenerators can be driven by irregular mechanical motion.

   A shown **B** is showing **C** has shown

4. We are interested in very small devices that _____ in applications such as health care, environmental monitoring and personal electronics.

   A be used **B** can use **C** can be used

5. The earliest zinc oxide nanogenerators _____ arrays of nanowires grown on a rigid substrate and topped with a metal electrode.

   A use **B** used **C** have been using

6. Regardless of the configuration, the devices _____ careful growth of the nanowire arrays and painstaking assembly.

   A required **B** requiring **C** is required

7. The wires were cut from their growth substrate and _____ into an alcohol solution.

   A placed **B** placing **C** was placed

8. Working at the nanoscale enables scientists to utilize the unique physical, chemical, mechanical, and optical properties of materials that naturally _____ at that scale.

   A occccuring **B** occur **C** occured

9. Scientists study these properties for a range of uses, from altering consumer products such as clothes to _____ medicine and tackling environmental issues.

   A revolutionize **B** revolutionized **C** revolutionizing

10. Buckyballs are _____ to exist in extremely harsh environments, such as outer space.

   A able **B** can **C** should

Taken from https://phys.org/news/2010-11-nanogenerators-strong-power-small-conventional.html

TRANSLATION

25. Choose the correct option.

1. Теоретичні дослідження графенових шарів розпочалися задовго до отримання зразків матеріалів.
   A. Theoretical studies of graphene layers began long before material samples were obtained.
   B. Theoretical investigations into graphene layers started after material samples were acquired.
   C. Theoretical research on graphene layers started after material samples were obtained.
2. У 2004 році було відновлено структуру графену, який є найміцнішим наноматеріалом.
   A. In 2004, the structure of graphene, which is the strongest nanomaterial, was restored.
   B. The strongest graphene structure was obtained and restored in 2004.
   C. Collecting and restoring the strong graphene structure occurred in 2004.
3. Графен має унікальні електронні й оптичні властивості для застосування в широкому діапазоні робочих частот.
   A. Graphene has unique electronic and optical properties for use across a sheer range of operating frequencies.
   B. The electronic and optical properties of graphene are unique and can be used in a broad spectrum of working posessions.
   C. For a wide range of operational frequencies, graphene possesses unique electronic and optical properties.
4. Можливості, що відкриваються людству завдяки нанотехнологіям, майже необмежені.
   A. The list of possibilities provided to humanity by nanotechnologies can be called infinite.
   B. Nanotechnologies offer an endless list of properties to humanity.

C. The finite possibilities provided by nanotechnologies can be given.

5. Наночастинки також можуть використовуватися для доставки хіміотерапевтичних препаратів до певних клітин, зокрема ракових.

A. Nanoparticles can also be used for delivering chemotherapeutic drugs to specific cells, such as cancer cells.

B. The utilization of nanoparticles comprises delivering chemotherapy drugs to accurate cells, like cancer cells.

C. Delivery of chemotherapeutic agents to specific cells, including cancer cells, can be fulfilled using nanoparticles.

Taken from ***https://www.imp.kiev.ua/nanosys/ua/articles/2022/1/nano_vol20_iss1_p0001p0013_2022_abstract.html***

SPEAKING

26. Work in pairs. Write three questions based on the text “Nanotechnologies: working big, thinking small” and fill in the table. Ask other students and note their answers. Compare the results with your partner.

	STUDENT 1	STUDENT 2	STUDENT 3
Q.1.			
Q.2.			
Q.3.			

27. Work in pairs. Ask each other questions and then share the most interesting answers with other students.

STUDENT A’s QUESTIONS (Do not show them to student B)

a) What is nanotechnology?

b) How big is a nanometer?

c) What are zero-, one-, two-, and three-dimensional nanomaterials?

d) How does nanotechnology work?

STUDENT B’s QUESTIONS (Do not show them to student A)

a) What is so special about nanotechnology?

b) What are nanomaterials?

c) What is graphene?

d) What are synthetic nanoparticles?

28. Look at the words below. With your partner, recall how they were used in the text and make up a short overview on the text in READING part of this unit including the following:

an armored exoskeleton, ambitious advancements, arranged by the sequence, build from the ground up, auto-repair mid-flight, to tailor the core structures, a miniaturization, embedded into, life-sized counterparts.

LISTENING

29. Before listening to some information about nanoparticle-based bio diagnostics, check the meaning of the following words and phrases:

nanotech, a nanoparticle, to enable, biomedical, to take on new properties, a major focus, an ability to bind, assay, medical diagnostics, disease diagnosis.

30. Scan the QR code. Listen to the part of the podcast "Impacting the World with Nanotechnology: A Conversation with Chad Mirkin" and decide whether the statements are true (*T*) or false (*F*).

1.	2.	3.	4.	5.

1. Chad Mirkin thinks nanotech is important for one specific type of technology.
2. Nanotech is going to play a role anywhere where new materials are important.
3. Chad Mirking believes that anything old becomes new when shrunk to the above 100 nanometer length scale.
4. The applications are driven by the discovered new properties.
5. Luminex sells VERIGENE systems, which is now in half the world's top hospitals.

31. Listen to the part of the podcast "Impacting the World with Nanotechnology: A Conversation with Chad Mirkin" for the second time and complete the sentences.

1. So, you mentioned developing capabilities and you've developed ____ and therapeutic tools.
2. We've really had a major focus on ____.
3. And a lot of the science is about ____ what those properties are.
4. In the area of bio diagnostics we learned very ____.
5. And so that property becomes ____ for very sensitive labels.

32. Before watching the video about the inspiration from nature for nanotechnology, check the meaning of the following words and phrases: complex, to synthesize, a toolkit, to manipulate, dissolved in the water, exquisite structure, a solar cell, to program a virus, to do one's bidding, molecular scissors, a sequence, to expose someone to something, to evolve, to tie into, bonding.

33. Scan the QR code. Watch the short clip "Inspiration from Nature" and decide whether the statements from the text are true (*T*) or false (*F*).

1.	2.	3.	4.	5.

1. The researcher/interviewer remembers reading the expert's work when he was a student.
2. Nature has figured out a way to synthesize not-so-complex nanostructures.
3. Angela Belcher believes that life has inspired us to create the toolkit on the nanoscale.
4. The interviewed expert's idea is to program microorganisms to build nanostructures.
5. The experts agree that instead of using conventional chemistry, we can train certain biological elements to do the work for us.

34. Watch the video "Inspiration from Nature" for the second time and complete the sentences.

1. It sounds like there could be an area of ____.
2. Biology is ____.
3. If you take this and fracture it, and you look at it in a scanning electron ____.
4. And you say, okay, that's ____.
5. How do you actually ____ to do your bidding?

WRITING

35. Investigate the topic of Nanotechnologies and write an overview (80-100 words) following the next structure:

1. Begin your assignment with a brief overview of nanotechnology, defining what it is and its significance in modern science and technology;

2. Explain the basic principles of nanotechnology, including nanoscale materials, structures, and processes;

3. Explore the historical development of nanotechnology and highlight key milestones that have shaped the field.

Represent it to your groupmates. Be ready to answer questions.

36. Make a poster about what nanotechnology actually is for a 6-year-old child to understand. Follow the instructions:

1. Create a catchy heading consisting of 3-4 words;
2. Add pictures or drawings;
3. Use simple language to describe the different scales;
4. Provide links to additional material.

Show your work to your groupmates. Compare the posters and choose the most informative and clear.

37. Choose a real or fictional company that specializes in nanotechnologies and write a letter of application. Remember to:

1. Emphasize your passion for innovation and your eagerness to be a part of a team that is pushing the boundaries of nanotechnology;
2. Demonstrate an understanding of the company's values and explain how your own values align with theirs;
3. Showcase your ability to work collaboratively in a team-oriented environment, as well as your capacity to take initiative when required.

EXTRA READING

38. Read Text A "Nanotechnology in Food Processing" (see EXTRA READING section to Unit 4) and decide whether the statements from the text are true (T) or false (F).

1.	2.	3.	4.	5.

1. Nanotechnology can help increase the shelf-life of different kinds of food materials and reduce food wastage due to microbial infestation.
2. Nanoparticles have no advantages over traditional encapsulation systems in terms of encapsulation and release efficiency or protecting active agents from degradation during processing and storage.
3. Particle size directly affects the delivery of any bioactive compound to various sites within the body, and submicron nanoparticles are absorbed more efficiently than larger-size micro-particles.
4. Nanosensors can be used to detect the presence of contaminants, mycotoxins, and microorganisms in food.
5. It's difficult to evaluate the success of nanotechnology implemented into food processing.

39. Read Text A "Nanotechnology in Food Processing" (see EXTRA READING section to Unit 4) and find the words to which the following ones are synonyms. Choose any three words and use them in the sentences of your own.

1	Intricate, comprehensive (para. 1)	***elaborated***
2	supplement, add-ons (para. 1)	**…**
3	rapport, unity (para. 3)	**…**
4	Infiltrate, invade (para. 3)	**…**
5	to aim, to achieve (para. 4)	**…**

40. Read Text B "Nanotechnology in Architectural Projects" (see EXTRA READING to Unit 4) and decide whether the statements are true (T) or false (F).

1.	2.	3.	4.	5.

1. Nanotechnology has little potential to remedy concrete product corrosion.
2. Nanostructures have the potential to repair damaged structural surfaces on their own.
3. Microcapsule rupture releases a healing ingredient that gradually repairs damaged concrete mix through capillary action and polymerization.
4. The biggest problem with using nanotechnology in architecture and buildings is related to economic factors.
5. Increased commercial use of nanomaterials has no impact on exposure levels or potential consequences.

41. Read Text B "Nanotechnology in Architectural Projects" (see EXTRA READING to Unit 4) and find the words to which the following are the synonyms. Choose any three words and use them in the sentences of your own.

1	improving, fixing, making better (para. 1)	***refining***
2	restoration, cure, panacea (para. 2)	…
3	dispatch, minimize (para. 6)	…
4	display, vulnerability (para. 7)	…
5	enterprise, undertaking (para. 8)	…

PROBLEM-SOLVING

42. Do the quiz (see the PROBLEM-SOLVING section in Unit 4).

Unit 5. ACOUSTICS

"We are slowed down sound and light waves, a walking bundle of frequencies tuned into the cosmos. We are souls dressed up in sacred biochemical garments and our bodies are the instruments through which our souls play their music."

Albert Einstein

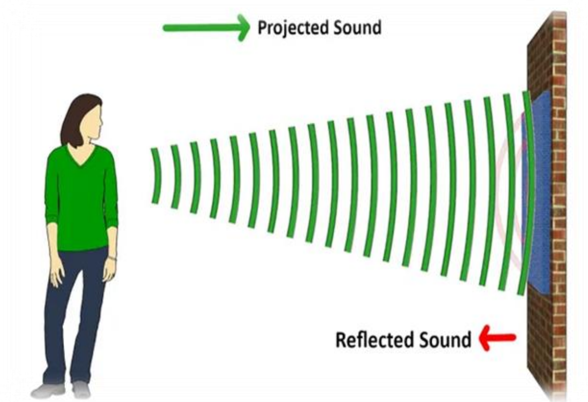
Taken from https://www.ravepubs.com/wp-content/uploads/2016/05/sound-frequency-0516.jpg

WARM-UP

1. Look at the pictures below and say how they might relate to acoustics.

Taken from https://media.istockphoto.com/id/1293175706/photo/sound-waves-in-color-abstract-modern-background.jpg?s=170667a&w=0&k=20&c=zaD0JjyGX2g7YvFYIIa16erDagKAy1FWsgtm01S3YVY=

A

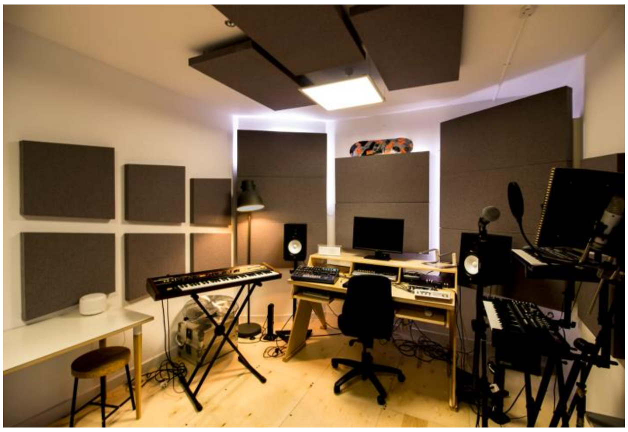


Taken from https://lirp.cdn-website.com/28aa4e38/dms3rep/multi/opt/absorption+image+2-640w.jpg

B

Taken from https://brucewilsongraphics.wordpress.com/2013/03/18/decibel-meter/

C



Taken from https://cdn.shopify.com/s/files/1/0088/3707/0933/files/Warp_Records_1_1440x.jpg?v=1613771193

D

2. Work in groups. Make up a list of words which you associate with the term "*acoustics*". Share your words with your partner(s).

3. In pairs, answer the following questions.

1. What is acoustics?
2. What is acoustic energy?
3. What are the types of acoustics?
4. What are the applications of acoustics?
5. What is an acoustician? What does an acoustician do?
6. Who is known as the "father of acoustics"?

4. Read the facts about acoustics below and decide if they are true (*T*) or false (*F*). Give your reasons.

1.	2.	3.	4.	5.	6.	7.

1. Infrasound, sometimes referred to as high frequency sound, describes sound waves with a frequency below the lower limit of human audibility (generally 20 Hz).
2. Environmental acoustics is concerned with vibration and noise caused by roadways, railways, aircraft, and general activities that are related to the environment.
3. The sound waves transport energy throughout the propagating medium.
4. There are two main characteristics of sound waves.
5. The more intense the sound is, the larger the amplitude oscillations will be.
6. One of the earliist precursors to the study of acoustics is music.
7. There are different subfields of acoustics, including noisy, music, ultrasound, infrasound, and vibrational.

READING

5. Underline the stressed syllable in each word as in the example. Practice reading:

archi<u>te</u>ctural, permeates, considerably, enhanced, emphasized, undesirable, insulation, enforceable, measurements, alterations, fluctuations, pebble, variables, analogies, throughout, transversal, longitudinal.

6. Read the text "The Basics of Architectural Acoustics" and decide whether the following statements true (T) or false (F).

1.	2.	3.	4.	5.

1. Noise is an unwanted sound judged to be unpleasant, loud, or disruptive to hear.
2. The quality of the acoustic environment affects our work, leisure, and rest.
3. Sound can be defined as the sensation produced by stimulation of the organs of hearing by vibrations transmitted through the air or other medium.
4. Sound cannot propagate through solids.
5. Airborne sound insulation describes the joining between rooms separated by a wall or floor partition.

7. Find synonyms to the words in bold from the text.

The Basics of Architectural Acoustics

Architectural acoustics can be defined as the study of the generation, propagation, and transmission of sound in rooms, dwellings, and other buildings. Architectural acoustics permeates every walk of modern life. Correct application of the principles of architectural acoustics can considerably **improve** the quality of life at work, during leisure time, and in the home. Some sounds are

Taken from https://akinco.ae/wp-content/uploads/2020/08/Noise-Control.png.

desirable and need to be enhanced or emphasized (e.g., music in a concert hall, the speaker's voice in a debating chamber, etc.), while other sounds are highly undesirable (known as noise) and need to be reduced or prevented (e.g., noise in a factory workshop, noise from a neighbour's party in the early hours of the morning, etc.). In many countries, minimum limits have been set for the permitted noise levels in a particular **environment** (e.g., in the home, at the place of work). Regulations have also been drawn up defining the minimum acceptable acoustic properties of building elements (e.g., walls, floors, doors) and the minimum acceptable sound insulation that should exist between adjoining dwellings. These regulations are sometimes recommendations and sometimes enforceable by law.

Careful thought about the acoustic **properties** of a proposed building at the design stage, perhaps in conjunction with the results from acoustic measurements on material samples and scale models, can often save much time and effort later on. It is frequently the case, however, that alterations have to be made to improve the acoustic properties of the finished building. To do this effectively, measurements usually have to be performed before a remedy can be proposed.

Sound is the sensation perceived by the human ear resulting from rapid fluctuations in air pressure. These fluctuations are usually created by some vibrating object that sets up longitudinal wave motion in the air.

Most people have some intuitive idea of what constitutes a wave. Almost everyone has seen ocean waves breaking on the seashore or has noticed the ripples that radiate away from the place where a pebble strikes the surface of a pond. Sound waves are a **particular** type of a general class of waves known as elastic waves. Elastic waves can occur in media that possess the properties of mass and elasticity. If a particle of such a medium is displaced, then the elastic forces present will tend to pull the particle back to its original position. The term particle of the medium **denotes** a volume element large enough to contain millions of molecules so that it may be considered as a continuous fluid, yet small enough so that such acoustic variables as pressure, density, and velocity may be thought of as constant throughout the volume element.

The displaced particle possesses inertia and can therefore transfer momentum to a neighboring particle. The initial disturbance can therefore be propagated throughout the entire medium. There are several **analogies** that can be drawn between the **propagation** of a sound wave and the propagation of the ripples on the surface of the pond. Both disturbances travel away from their respective sources at a constant speed. Both disturbances propagate by an exchange of momentum and there is no net transfer of matter away from the sound source just as there is no net fluid flow in the pond. The important **distinction** is, however, that the ripples are propagated by transversal waves whereas sound in air is propagated by longitudinal waves.

Sound can propagate throughout a building either via the air or via the building's structure. Sound generation mechanisms can therefore be divided into two general groups.

One group consists of those sources that **generate** sound directly into the air such as the voice, loudspeakers, etc. Insulation against such sound is called airborne sound insulation.

The other group consists of those sources which act directly on the structure of the building usually by means of impact or vibrating equipment. Transmission of the sound is then through and from the structure. Examples are footsteps, noisy plumbing installations, and slamming doors.

Taken from https://www.bksv.com/media/doc/bn1329.pdf

8. Look through the list of words and phrases and check if you know their Ukrainian equivalents. Take turns to ask each other. Use MINI-DICTIONARY section to Unit 5 if necessary.

a propagation	a pond
a dwelling	density
to permeate	velocity
considerably	pressure

to draw up	distinction
to adjoin	transversal waves
in conjunction with	to constitute
sensation	throughout
fluctuations	net
longitudinal waves	via
ripples	an insulation
to radiate	plumbing

USE OF ENGLISH

9. Explain the meaning of the words and phrases taken from the text:

propagation of sound, to be enhanced, a debating chamber, in conjunction with smth., a design stage, scale models, to have some intuitive idea of smth., to possess the properties of smth., a displaced particle, via the air, sound insulation, slamming doors.

10. Cross the odd word out, explain why. The first is done for you.

1) obscuring, ***~~propagation~~***, constraining, veiling;
2) enhanced, increased, expanded, diminished;
3) properties, features, controversies, attributes;
4) distinction, resemblance, congeniality, proximity;
5) generate, spawn, manufacture, prevent.

11. Match the words (1-8) with their definitions (a-h).

1.	desirable	***a***	occurring continuously over a period of time

2.	acoustic	***b***	the intervening substance through which impressions are conveyed to the senses or a force acts on objects at a distance
3.	fluctuation	***c***	the degree of compactness of a substance
4.	medium	***d***	a difference or contrast between similar things or people
5.	density	***e***	wanted or wished for as being an attractive, useful, or necessary course of action
6.	constant	***f***	the surroundings or conditions in which a person, animal, or plant lives or operates
7.	distinction	***g***	relating to sound or the sense of hearing
8.	environment	***h***	an irregular rising and falling in number or amount; a variation

12. Use the words from exercise 11 to complete the sentences. Change the word form if necessary. Use each word once. The first is done for you.

1. Boyle then came to the correct conclusion that a ***medium*** such as air is required for the transmission of sound waves.
2. For on-site measurements, portable equipment is highly ____.
3. Despite the important role of ____ materials, one shouldn't overdo them and remember that visitors are also absorbing middle and high frequencies.
4. The amount of energy per unit volume of a sound wave is measured by a quantity known as the energy ____.
5. Symphonia allows to simulate a realistic sound ____.

13. Match the words/phrases in the left-hand column with ones in the right-hand column to make collocations from the text. Use each word/phrase only once. Translate the collocations into Ukrainian.

1	surface	***a***	as a continuous fluid
2	considerably improve	***b***	acoustic properties
3	pull the particle back	***c***	sound insulation
4	minimum acceptable	***d***	wave motion
5	be considered	***e***	plumbing installations
6	acoustic	***f***	to its original position
7	entire	***g***	the quality of life
8	longitudinal	***h***	of a pond
9	airborne	***i***	measurements
10	noisy	***j***	medium

14. Fill in the gaps with the appropriate words from the list below. Use each word only once. The first is done for you.

zero, loudness, hearing, medium, barely, ~~solid~~, value

Sound waves require a **(1)** ***solid***, liquid, or gas (the medium) to travel through. They are mechanical waves. They cause particles (atoms and molecules) of the **(2)** ____ to move (vibrate). The young healthy ear has an audible range of ~20 Hz to ~20 000 Hz. However, sounds of different frequencies stimulate our **(3)** ____ by different amounts. Our ear is most "sensitive" between 500-6000 Hz. It is not very sensitive below 200 Hz or above 12 000 Hz. A sound's intensity (in watts per square meter, W/m2) is the objectively measurable amount of sound energy carried by a sound. A **(4)** ____ as low as 10-12 W/m2 is at our threshold of hearing and may be called silence. The human perception of the **(5)** ____ of a sound is called "sound level" and is expressed in decibels (dB). A sound level of 0 dB is perceived as silence. This does not mean that the amount of sound energy is **(6) ____**, just that we can't hear it! We can also hear a sound energy of 1 W/m2 as a painful (and ear-damaging) sound level of 120 dB.

Two sounds that differ by 0.1 dB can **(7) ____** be perceived as different in loudness while a sound that is 3 dB louder than another, sounds twice as loud. Continuous noise at 90 dB will, over time, produce hearing damage without causing pain.

15. Rearrange the letters in bold to make words that fit into the gaps. The first is done for you.

Due to the nonlinearity of the governing equations, it is very difficult to predict the sound **(1)** ***<u>production</u>*** **(nrtodpucio)** of fluid flows. This occurs typically at high-speed flows, for which nonlinear inertial terms in the equation of motion are much larger than the viscous terms (high Reynolds numbers). As sound production represents only a very minute fraction of the energy in the flow the direct prediction of sound generation is very difficult. This is particularly dramatic in free **(2) ____** (**epasc**) and at low subsonic speeds. The fact that the **(3) ____ (sdonu)** field is in some sense a small perturbation of the flow, can, however, be used to obtain approximate solutions.

Aeroacoustics provides such approximations and at the same time a **(4) ____ (efidniiont)** of the acoustical field as an extrapolation of an ideal reference flow. The difference between the actual flow and the reference flow is identified as a source of sound.

This **(5) ____ (eiad)** was introduced by Lighthill who called this an *analogy*. A second key idea of Lighthill is the use of integral equations as a formal solution. The sound field is obtained as a convolution of the Green's function and the sound source. The Green's function is the linear response of the reference flow, used to define the acoustical field, to an impulsive point source. A great **(6) ____ (dvaanetag)** of this formulation is that random errors in the sound source are averaged out by the integration. As the source also depends on the sound field this expression is not yet a solution to the problem. However, under free field conditions, one can often neglect this feedback from the **(7) ____ (aoausctIcl)** field to the flow. In that case, the integral formulation provides a solution.

16. Fill in the table with the words derived from the given ones. The first is done for you.

Verb	Noun	Adjective
apply	***application***	***applied***
…	…	considerable
regulate	…	…
…	acceptance	…
…	…	proposed
denote	…	…
…	neighbour	…
…	…	extrapolation

17. Study information in the table below. Then fill in the correct phrasal verb. Change the form of the verbs where necessary. The first is done for you.

hear from smb.	to get a call, email or other form of communication from someone
hear of	to know about somebody/something because you have been told about them; to know of someone or something's existence; to refuse to accept something (negative use)
hear out	to listen to everything someone is saying
listen in	listen, especially secretly, without saying anything; listen quietly

listen for	to listen carefully so that you will notice a particular sound; to try to hear someone or something

1. I haven't ***heard*** anything ***from*** her for months.
2. I've ____ this wave model before.
3. Everything we ____ that scientist was exceptional.
4. They can produce loud clicks and ____ echoes from the sea floor in order to orient.
5. I'm trying to honestly ____ all the participants of the seminar.
6. Even if we scan their private frequency, we can't ____.
7. Turn the rotor manually and ____ unusual noises.
8. They will patiently ____ and give advice.
9. He's supposed to be a famous scientist, but this is the first time I've ever ____ him.
10. We have to really ____ utter internal quiet, and to be tuned into the correct wavelength.

18. Match the parts (1−5) in the left-hand column with the right-hand column (a−e) to make complete sentences.

1.	The origin of the science of acoustics is generally attributed to the Greek philosopher Pythagoras (6th century BC),	***a***	just as in the present time, so music became a medium of expression.
2.	Acoustics is a branch of physics	***b***	relate to the understanding and application of a methodology for the recognition, evaluation and prevention or control of noise as an occupational hazard.

3.	Fundamental aspects of acoustics	***c***	which means there's a fixed ratio between measurement units.
4.	Life in prehistoric society was fraught with emotion,	***d***	whose experiments on the properties of vibrating strings that produce pleasing musical intervals were of such merit that they led to a tuning system that bears his name.
5.	The dB scale is logarithmic,	***e***	that is concerned with the production, control, transmission, and effects of a sound.

19. Choose and underline the acceptable word. The first is done for you.

Scientists and engineers have a very **(1) questionable /** ***rigorous*** definition of what constitutes "knowing." Fundamentally, scientific knowledge relies on testable hypotheses that can be verified (or falsified) **(2) experimentally / fuzzily** and that have successfully withstood such tests. If we say that we understand any given process or phenomenon, we mean that we can express that understanding using mathematics and we can **(3) make / suppose** a quantitative calculation based on those mathematical expressions that will predict the outcome of a particular process or a specific situation, even if that device never existed or the process has never been observed before. Furthermore, our "understanding" permits us to estimate the **(4) uncertainty / unmistakable** limits of those predictions. When that new process is executed, or that new device is created, the measured outcome or performance will have the predicted value within the predicted limits, if we have "understanding."

The **(5) mathematics / mathematical** understanding must be supplemented by a "clear and intuitively satisfying narrative." When we have that, along with predictive mathematics, we can usually intuit qualitative predictions before we make quantitative predictions; the qualitative and quantitative understandings provide a check on each other.

Scientists have two fundamentally different ways of understanding natural **(6) phenomens / phenomena** on the scale sizes of human interest. These scales typically range from the "microscale," characterized by devices that have dimensions that are on the order of **(7) microns / macros**, to the "macroscale," such as the Earth's oceans and atmosphere, that have characteristic length scales in the thousands of kilometers.

20. Underline the correct answers to complete the sentences. The first is done for you.

1. Acoustic variables are those things ***who / <u>which</u> / whose*** change due to a mechanical interaction of the sound wave with a medium and include pressure, density, temperature, and particle motion.
2. Specular reflection is responsible for ***formed / form / forming*** the edges of the ultrasound image and occurs best when the beam is perpendicular to the edge in question and worst when the beam is parallel to the edge in question.
3. Spatial resolution ***measure / is measured / measures*** in units of distance such as *mm*.
4. Even in the audible range, the human ear is not ***equality / equal / equally*** sensitive to all frequencies.
5. In music performance and recording, electric echo effects ***have been used / used / being used*** since the 1950s.
6. A true echo is a single ***reflects / reflection / reflections*** of the sound source.
7. If the mixture of sounds ***creates / create / creating*** an unpleasant impression, it becomes hard to distinguish individual sounds with a short reverberation time.
8. The person who is an expert in the field of acoustics ***knows / is known / know*** as an acoustician.
9. These days, acoustics technology is very much applicable in ***many / much / more*** industries to reduce the noise level.

10. In concert halls built for a large number of visitors, the sound should be scattered perfectly for the rear seats to be ***ability / abilities / able*** to hear the music.

21. Fill in the gaps with the correct prepositions. The first is done for you.

1. Loudness is a subjective characteristic ***of*** a sound (as opposed to the sound-pressure level in decibels, which is objective and directly measurable).
2. The unit decibel is used because a one-decibel difference in loudness ____ two sounds is the smallest difference detectable by human hearing.
3. The study of sound should begin ____ the properties of sound waves.
4. Sound levels for audio systems, architectural acoustics, and other industrial applications are most often quoted ____ decibels.
5. In addition ____ the geometric decrease in intensity caused by the inverse square law, a small part of a sound wave is lost to the air or other medium through various physical processes.
6. ____ normal conditions the Sun heats the Earth and the Earth heats the adjacent air.
7. Because many musical instrument families have similar spectra, there must be other factors that affect their tone quality and ____ which their tones can be distinguished.
8. ____ the other hand, the clarinet functions acoustically as a closed tube, because it is cylindrical in shape and has a reed end.
9. Reverberation time is defined as the time needed to reduce sound pressure level ____ 60 dB after turning off the sound source.
10. Every seat in a concert hall is unique, from the point of view ____ acoustics.

22. Correct the grammar mistakes in the following sentences as in the example given below. There is one mistake in each sentence. The first is done for you.

1. This type of sound generation mechanism has ~~***being***~~ discussed in detail by Morfey and Dowling.	***Been***

2. Using the monopole solution, we can built more complex solutions.	
3. Modes can also be obtain in more complex situations.	
4. Two special kinds of spectra is commonly referred to as white random noise and pink random noise.	
5. Frequency analysis may be thought of as a process by which a time varying signal in the time domain is transformed to it's frequency components in the frequency domain.	
6. Most musical tones differ from the demonstration tone in that they consist from more than a single wave form.	
7. Composers of electronic music have utilized this capability to synthesize tones quite difference from any available on traditional instruments, as well as tones similar to natural sounds.	
8. Listener seats on a chair surrounded by loudspeakers, that are located 3 meter from him, in a special room.	
9. It's worth mention the main mistakes that can be faced when making a project of a concert hall.	
10. The characteristics and the directivity pattern of the sound generated by each types of source may vary considerably.	

TRANSLATION

23. Choose the correct item.

1. Звук має ті ж ознаки хвильового явища, що і світло та радіосигнали.

A. Sound possess the attributes of wave phenomenas, as do light and radio signals.
B. Sounds possess the attributes of wave phenomena, as is light and radio signals.
C. Sound possesses the attributes of wave phenomena, as do light and radio signals.

2. Акустика включає в себе процес створення звуку, передачу звуку через тверді тіла та вплив звуку на інертні та живі матеріали.
A. Acoustics deals with the creation of sound, sound transmission through solids, and the effects of sound on both inert and living materials.
B. Acoustics deals off the creation of sound, sound transmission through solids, and the effects of sound on inert and both living materials.
C. Acoustic deals with the creation of sound, sounds transmission through solid, and the effects of sound on both inert and living materials.

3. Сер Френсіс Бекон вважав звук однією з «найвитончених частинок природи».
A. Sir Francis Bacon deems sound to be one of "subtlest pieces of nature".
B. Sir Francis Bacon deemed sound to be one of the "subtlest pieces of nature".
C. Sir Francis Bacon deemed sound to be ones of the "subtlest pieces of nature".

4. Сучасна акустика суттєво відрізняється від тієї, яка існувала за часів Бекона.
A. Modern acoustics is vastly different from the field that existed in Bacon's time.
B. Modern acoustic is vastly differed from field that existed in Bacon's time.
C. Modern acoustics are vastly difference between the field that existed in Bacon's time.

5. Ця група складається з джерел, які генерують звук безпосередньо у повітрі.
   A. Group consists of that sources which generate sound directly into the air.
   B. One group consist of these sources which generate sound directly into the air.
   C. This group consists of sources which generate sound directly into the air.

Taken from https://www.arauacustica.com/files/publicaciones_relacionados/pdf_esp_198.pdf

SPEAKING

24. Do you agree with the following quotations? Give reasons for your answers. Use the phrases: *In my opinion…, as for me / as to me…, as far as I'm concerned..., if you ask me..., according to…, it seems to me that…, I have come to the same conclusion…, I have no doubt that…, I'm afraid I disagree…, I think otherwise…, that's not always / necessarily true…,* **etc.**

1. "With real estate, it's location, location, location. In public speaking, it's acoustics, acoustics, acoustics."

   Christopher Buckley

2. "Words have not only a definition... but also the felt quality of their own kind of sound."

   Mary Oliver

3. "Get someone else to blow your horn and the sound will carry twice as far."

   Will Rogers

4. "The empty vessel makes the loudest sound."

   Plato

5. "It's all about sound. It's that simple."

   Eddie Van Halen

25. Work in pairs. Answer the following questions.

1. What comes to mind when you hear the word "sound"?
2. What are your favourite sounds?
3. Do you like the sound of your own voice?
4. Which do you think sounds better: digital sound or analogue sound?
5. What sounds from nature do you like most?

26. Prepare a short three-minute presentation for your groupmates on one of the topics below. Use not more than 6 slides in your presentation.

1. Acoustics throughout history.
2. Evolution of architectural acoustics.
3. The first studies of underwater acoustics.
4. Fundamentals of acoustics.
5. Archaeoacoustics: the study of acoustics at archaeological sites.

LISTENING

27. Before listening to some information about Sun's sounds, check the meaning of the following words and phrases:

a solar observatory, solar flares, phenomena, surface, to turn data from smth., straightforward, to bounce around, sensitive, layers of the Sun, a probe.

28. Scan the QR code. Listen to the text about Sun's sounds and decide whether the statements from the text are true (T) or false (F).

1.	2.	3.	4.	5.

1. Three space agencies joined together in this research.

2. Scientists can now know more about the inside of the Sun.
3. Scientists said they have a big microscope to look at the Sun.
4. Scientists said many people could see waves bouncing around the Sun.
5. A scientist said it was cool that we could probe inside a star.

29. Before watching the video about how sound works in rooms, check the meaning of the following words and phrases:

flat ceilings, direct sound, reflected sound, to bounce off, flat surface, interference patterns, bounce angle, an absorber, a diffusor, to scatter, to smooth out.

30. Scan the QR code. Watch the video "How Sound Works (In Rooms)" and decide whether the statements from the text are true (T) or false (F).

1.	2.	3.	4.	5.

1. Most rooms have convex walls and flat ceilings, and sound bounces off these.
2. Reflected sound arrives at our ears as fast as direct sound.
3. To a sound wave, an absorber looks a little like a hole in the wall.
4. Overly absorbent rooms are preferable for humans than traditional ones.
5. A diffusor smoothes out destructive interferences throughout the room.

31. Watch the video for the second time and complete the sentences.

1. The blue pattern represents ____ sound waves.
2. Sound travels really fast – about ____ feet per second.
3. Both discs bounce together in the same direction, which means the ____ is at full strength.
4. If we use only ____ in a room, it makes it sound dull and unnatural.
5. Room acoustics are greatly improved using a combination of absorption and ____.

WRITING

32. Choose one of the statements below and write an argumentative essay (use up to 160 words). Use the phrases: *to begin with***…,** *on the contrary*…, *to put more simply*…, *all things considered*…, *to clarify*…, *at the same time*…, *by contrast*…, **etc.**

1. "Science is the great antidote to the poison of enthusiasm and superstition."

   Adam Smith
2. "Reason, observation, and experience; the holy trinity of science."

   Robert Green Ingersoll
3. "An expert is a person who has made all the mistakes that can be made in a very narrow field."

   Neils Bohr
4. "There's real poetry in the real world. Science is the poetry of reality."

   Richard Dawkins
5. "Science has made us gods even before we are worthy of being men."

   Jean Rostand

33. Write a short summary of the text "Architectural Acoustics" (50−60 words). Follow these steps:

✓ **Read the text.**

- ✓ **Make notes of the main points of the text.**
- ✓ **Start your piece of writing with one sentence that summarizes the idea of the whole text.**
- ✓ **Write your summary, including all the main points. Use your own words.**

34. Work in small groups. Make a crossword puzzle on the topic "Acoustics". Exchange the crossword puzzles and solve them.

35. What sounds do you like and dislike from these places? Complete the chart given below with your partner(s). Share what you wrote with your partner(s).

	Like	**Dislike**
The city		
The beach		
Forests		
Your home		
Shopping malls		
Mountains		

EXTRA READING

36. Read Text A "The Nature of Music" (see EXTRA READING section to Unit 5) and and choose the correct item A, B, C or D.

1. Why did the author write the text?

A. To describe the music for some animals, including humans.

B. To illustrate the importance of musical instruments to human beings.

C. To show that music is a modern invention.

D. To suggest that music is independent of life forms that use it.

2. According to the text, which of the following is true of humpback whales?

A. Their tunes are distinctively different from human tunes.

B. They can sing over a range of seven octaves.

C. They do not use rhyme, unlike humans.

D. Whale songs of a particular group cannot be learned by other whales.

3. Which of the following is NOT true about humpback whale music?

A. It uses similar patterns to human songs.

B. It's comparative in length to symphony movements.

C. It's easy to learn by other whales.

D. It's in the form of creating a theme, elaborating, and revisiting in rhyming refrains.

4. The word "*They*" in italics (para. 2) refers to ___.

A. human composers

B. whole songs

C. octaves

D. whales

5. Which of the following can be inferred from the text?

A. The earliest human beings came from France and Slovenia.

B. Music helped to shape the whale brain.

C. Humpback whales imitate the human vocal in creating their own notes.

D. The research of the musical brain will lead to the discovery of universal music.

37. Read Text A "The Nature of Music" (see EXTRA READING section to Unit 5) and find the words to which the following ones (1-5) are the synonyms. The first is done for you.

1.	complex, exquisite (para. 1)	***sophisticated***
2.	suggest, offer (para. 1)	…
3.	pristine, early (para. 1)	…
4.	neighboring, contiguous (para. 2)	…
5.	all-purpos140ondialial (para. 2)	…

38. Read Text B "A Capsule History of Acoustics" (see EXTRA READING section to Unit 5) and find the words which match the following definitions. The first is done for you.

1. Clear or obvious to the eye or mind (para. 1) – ***manifest***.
2. An agency or means of doing something (para. 2) – ____.
3. Forming a necessary base or core; of central importance. (para. 3) – ____.
4. Arranged according to an organized system (para. 4) – ____.
5. Suppose that something is true without having evidence to confirm it. (para. 5) – ____.

39. Read Text B “A Capsule History of Acoustics” (see EXTRA READING section to Unit 5) and match the words/phrases (1-5) in the left-hand column with ones in the right-hand column (a-e) to make collocations from the text. Use each word/phrase only once.

1.	a medium of	***a***	listening
2.	human interest in	***b***	the pitch of a sound and the five elements: earth, water, air, fire, and wind
3.	a relationship between	***c***	the length of a vibrating string with its pitch
4.	pleasurable	***d***	acoustics
5.	the inverse proportionality of	***e***	expression

PROBLEM-SOLVING

40. Do the quiz (see the PROBLEM-SOLVING section to Unit 5).

APPENDIX 1. EXTRA READING

UNIT 1. PARTICLE PHYSICS

TEXT B

BRAVE NEW WORLD

At first sight, the standard model looks relatively simple. The 18 particles are divided into fermions (the actual constituents of matter) and bosons (which carry the forces that allow fermions to interact). The fermions themselves are divided into two groups, the quarks and the leptons. Each of these comes in three generations, or "flavors", of successively heavier species. The first generation consists of the ingredients of everyday matter. Its quarks, the up and the down, are the bits inside protons and neutrons, the constituents of atomic nuclei. The first generation of leptons consists of the electron (the third constituent of atoms) and its corresponding neutrino – a particle so small that people are still arguing about whether it has any mass at all. Particles of the second and third generations are mostly short-lived and so rarely found outside particle-physics laboratories, though they were common at the beginning of the universe. The second generation's quarks are known as charm and strange; its leptons are the electron-like muon and the muon neutrino. The quarks of the third generation are called top and bottom; its leptons are the tau and the tau neutrino.

The most familiar of the bosons is the photon – the particle of light. Photons carry the electromagnetic force, the weakest in the standard model, and have no mass. The second force in the model, known as the weak nuclear force, controls radioactive decay. It is stronger than the electromagnetic force, but operates at a shorter range, and is carried by three bosons, the w+, the w- and the z. Weak bosons, unlike photons, are massive. The model's third force, known as the strong nuclear force, is the most powerful of the three. It holds quarks, and thus atomic nuclei, together. This force is carried by particles known as gluons. To confuse matters further, the strong nuclear "charge" comes in three varieties, known to physicists as red, green and blue. Because of their different "colors" each quark comes in three varieties, and there are eight distinguishable gluons. Gluons, like photons, are massless.

All very neat. But then there is – or at least there ought to be – the Higgs. The Higgs boson was the standard model's first "kludge". The model's original mathematics had the inconvenient consequence that they failed to predict the existence of mass. Introducing the Higgs boson solved this, and also explained why, among all the other bosons, weak-nuclear ones are the only ones with mass: the Higgs has no electric or color charge, and so it conveniently affects only the weak force. But the original calculations about the Higgs gave it, and in turn the z and the two w particles, a near-infinite mass. Physicists had to rid themselves of this annoying problem (called "unnaturalness") by using a bit of mathematical trickery to add appropriate fiddle factors to their equations. Its failure to solve the unnaturalness problem more convincingly is one of the main outstanding defects in the standard model.

It is not, however, the only one. Another defect is that the model fails to account for the most ubiquitous force of nature, gravity. A third, called the flavor problem, has two parts. One is the puzzle of why there are three and only three generations of fermion, given that the second and third generations seem almost redundantly similar to the first, except for their higher masses and shorter lifetimes. The other is why the particles in each generation have the masses that they do. (These range from the imperceptible for neutrinos, to something larger than a gold atom for the top quark.) The fourth mystery, the hierarchy problem, is why the different forces operate at such different energies, whether they are actually all manifestations of the same underlying phenomenon, and how they can be united mathematically if they are.

Kludging all of these problems in the way that was done for the Higgs would be hard. It would also be unsatisfactory. Most physicists have a deeply held belief that universal laws should be elegant, so what they are looking for is not a kludge, but a better theory. Such a theory would reduce the standard model, too, to an engineer's approximation. But it might prove to be a stepping-stone to a real theory of everything.

TEXT C

TESTING TIMES

The main problem, however, in testing technicolor and supersymmetry is that they generally predict particles with masses too large to be created at the energies probed by today's particle accelerators. So, finding out which, if any, of the new theories is right will probably be the job of new machines now under construction – the improved Tevatron, and the new Large Hadron Collider at CERN which is due for completion by 2005 and will smash protons together at 14 trillion electron volts, the highest energy ever achieved in a laboratory.

Finding gems among the dross of familiar particles that these machines will inevitably generate will, however, be hard. Big accelerators create around 10 million collisions a second. Physicists are able to track and record only 50 or so of these. This means they have to choose those that look interesting. That, in turn, requires a system of computers that can judge what is interesting within microseconds – filtering out the numerous "standard" events and recording only those with distinctive features that make them stand out from the crowd. Existing systems designed to do this have expectations of what to look for built into them. That has worked for the standard model because its predictions are relatively clear. But the new physics requires a new approach, and that is provided by some physicists at DO. They have invented a new computer program called "Sleuth".

John Womersley, the coordinator of DO, believes that Sleuth is the first truly model-independent way of analyzing data that has become available in the search for new physics. It works by comparing the range of standard-model predictions for the momentum and missing energy of decay products with those that are observed experimentally. If an intruder is hiding among those products, Sleuth will spot that there is something wrong and alert its masters. Although this will never be as sensitive as a targeted search, Dr. Womersley argues that, unlike present analytical methods, it is open to any kind of new particle – even those accounted for by theories that have yet to be dreamed up.

All in all, then, it looks as though the standard model has had its day – or soon will have had. The question is, when will its successor be clear? According to Dr. Ross, the lightest supersymmetric particles should already be accessible to accelerators, so fans of that theory should be getting nervous that nothing definite has yet turned up. Dr. Womersley agrees that physicists must see something soon. He believes that the standard model will be overthrown within the next five years. But which of the contenders will actually make it into the textbooks that physics students 100 years hence will peruse remains to be seen. Watch this space – however many dimensions it turns out to have.

Taken from https://www.economist.com/science-and-technology/2000/10/05/new-realities

Text D

DO HIDDEN INFLUENCES GIVE NEUTRINOS THEIR TINY MASS?

1. Undiscovered particles

The quest to understand the small mass of neutrinos is also a quest to discover new particles. Neutrinos are the byproducts of astronomical events that give us life. They shoot out from the nuclear fusion reaction within the sun and radiate from supernovas. They have no charge and curiously little mass. They are the second most abundant particle in the universe (after photons), and trillions of them are passing through your body each moment. Yet so much is still unknown about neutrinos.

Among the many open questions about neutrinos is how, exactly, they get their mass; the Standard Model of particle physics does not provide an answer. Many theories that explain the small masses of neutrinos also predict the existence of undiscovered particles, so one way to test those theories is to look for those particles.

2. ____________________

Most fundamental particles – like quarks and leptons – gain mass via interactions with the Higgs field. Some particles, like the massive top quark, interact more with the Higgs field, while other particles, like the light electron, interact less. If neutrinos gain their mass from the Higgs field, they seem to interact with it to an even smaller degree than the electron – much smaller; the mass of the neutrino is about a million times lighter.

That alone strikes scientists as strange. But there's another reason they wonder whether the neutrino gains its mass only from the Higgs. When a particle interacts with the Higgs field, the Higgs field switches that particle's "handedness" – a measure of its spin and motion. When a "right-handed" electron interacts with the Higgs field, it becomes a left-handed electron. When a left-handed electron interacts with the Higgs field, the opposite occurs. But as far as scientists have measured, all neutrinos are left-handed. Something else seems to be going on, and physicists have dozens of theories about what. "It's an embarrassment of riches," says Tao Han, a theoretical physicist at the University of Pittsburgh. "We have many theories, but we don't yet know which one reflects nature."

3. ____________________

Perhaps the simplest-seeming explanation is that right-handed neutrinos do exist; scientists just haven't seen them yet. What's not simple about this explanation is that those right-handed neutrinos would need to look much different from the neutrinos we know. Whereas neutrinos are almost massless, right-handed neutrinos would likely need to be much more massive than even the heaviest fundamental particle, the top quark. The explanation for this is called the "seesaw mechanism" because it predicts that the heavy, right-handed neutrinos are the reason left-handed neutrinos are so light; the right-handed neutrinos are holding down one side of the metaphorical seesaw. It all comes down to the math of what physicists call the eigenvalue, a property of how the system behaves. The seesaw model proposes that neutrinos have two eigenvalues, and if one is small, the other must be large to compensate.

4. _____________________

Physicists have posited many versions and variations of this mechanism. In one, the right-handed neutrino would be so heavy that it would have been produced only in the early universe, at which point everything was awash in enough energy for the electromagnetic, weak and strong forces to have been unified into one. In fact, the type of theory that unites these forces – called a Grand Unified Theory – already predicts the existence of right-handed neutrinos. That kind of built-in reasoning appeals to theoretical physicists like Mu-Chun Chen. "It gives a reason why the right-handed neutrino mass must be heavy and tied to the GUT scale," says Chen, a professor at the University of California, Irvine. "It's very elegant."

A second version of the seesaw mechanism also predicts a new kind of Higgs boson, which would allow a left-handed neutrino to couple to itself and indirectly interact with the new Higgs particle to gain mass. This new Higgs particle would be much heavier, acting as the heavy end of the seesaw. This sort of theory appeals to Han, since the Higgs sector "is still so unknown." "Why would we just have one particle that's responsible for mass generation?" he says. "We have fifteen orders of magnitude between the lightest particle and the heaviest. I think there is more in the Higgs sector than we have seen so far."

A third version of the seesaw mechanism predicts a new set of other massive matter particles that would offset the low masses of neutrinos. Physicists have developed models that combine these three, as well as other variants with names like "inverse" and "double" seesaws. Not everyone is on board with these ideas.

One problem is that the predicted particles are so massive, physicists don't yet know how to build a particle accelerator powerful enough to study them. "The seesaw mechanism is aptly named after a children's toy," says Patrick Huber, theoretical physicist at Virginia Tech. "It's a classic example of a theory that's very hard to test and prove." Another issue is that all seesaw models predict that the neutrino functions as its own antiparticle. So far, scientists have not seen evidence that this is true. And if it were, it would break another established law of physics called lepton number conservation.

5.______________________

Not every theory that explains the small mass of neutrinos is seesaw-related. Another one, called "radiative mass generation," proposes that neutrinos gain their mass through quantum effects of virtual particles. But radiative mass generation also requires the existence of new particles to work. So far, no experimental data has directly correlated to any of these models.

"The physics of neutrino mass is like the physics of dark matter, in the sense that we really have almost no idea what dark matter is," says Pedro Machado, a theoretical physicist at the US Department of Energy's Fermi National Accelerator Laboratory. "When it comes to neutrino mass models, popularity is not an argument. All viable models are equally good from the point of view of the data."

That is to say, physicists need more data. "Neutrino theory has a terrible track record in predicting anything," Huber says. "But we are about to enter an era of precision neutrino measurements, which could be a probe to look for new physics. We have these theories, and if a measurement confirms a theory, it is exciting for the person who made the theory. But if an experiment finds something that nobody predicted, it would be exciting for everybody." Physics experiments around the world are trying to understand neutrinos and their masses – and, perhaps, find a sign of a new particle that could help explain it all. "Since there are so many possibilities, the most useful thing is to cast a wide net and to consider as many different possibilities as we can," Machado says. If the explanation winds up pushing physics beyond our current understanding, he says, "then that is what we have been waiting for."

Taken from https://www.symmetrymagazine.org/article/do-hidden-influences-give-neutrinos-their-tiny-mass?language_content_entity=und

Text E

THE SEARCH FOR THE STERILE NEUTRINO

1. A dare prediction

In Germany in 1930, a group of scientists held a conference on nuclear physics, and they invited Wolfgang Pauli. The Austrian physicist was known as the originator of the Pauli exclusion principle, work that furthered scientists' understanding of matter and would eventually earn Pauli a Nobel Prize in Physics.

Pauli couldn't attend the German conference; he had a conflict in Zurich. Instead, he sent the attendees a letter that would turn out to be one of the more significant correspondences in physics history. In it, he predicted the existence of what would eventually be known as the neutrino. Scientists have since discovered and studied the properties of the theoretical particle. But big questions remain, including whether an undiscovered type of neutrino could be hiding from researchers' detectors. Back when it was theorized, scientists weren't sure they would ever detect the neutrino; now they're searching for a version of the particle that could be even more elusive.

2. ______________________

In his letter to the conference attendees, Pauli detailed ideas he'd had about beta decay, a process that had been troubling the nuclear physicists. In beta decay, an unstable atom releases energy in the form of a particle (called a beta particle). Scientists studying beta decay found that the energy of the beta particle was not enough to account for the total energy the decaying atom lost. Pauli had an idea about where the missing energy could be. He posited that an atom undergoing beta decay actually emitted more than one particle; it was just that the second particle had neither charge nor mass and was therefore undetectable by the technology of the day.

That was the problem, though. If the particle were undetectable, there would be no way to test whether Pauli's theory was correct. Pauli lamented that proposing the existence of an undetectable particle was "something no theorist should ever do" and kept the letter informal rather than write an official paper about an idea he was too uncomfortable to fully claim.

But the idea of an energy-carrying “ghost particle” resonated with many researchers, including Enrico Fermi. A few years later, Fermi figured out a complete theory of nuclear beta decay incorporating the new particle, which he christened the “neutrino.” Fermi theorized that the neutrino interacted through an unknown force, now known as the weak force, which interacts only at extremely short range. Not all scientists were as pessimistic as Pauli about detecting the neutrino. Physicist Walter Baade even made a bet with Pauli that his undiscoverable particle would one day be found.

In the 1950s, physicists Clyde Cowan and Fred Reines at the US Department of Energy’s Los Alamos National Laboratory designed a detector to catch neutrinos. It would detect the particles passing through and occasionally interacting via the weak force. To ensure they’d nab a few, they planned to set up their device near the most extreme collection of unstable atoms undergoing beta decay that they could create: a nuclear blast. Aside from the technical challenges it would take to study a nuclear explosion, it turned out that a nuclear bomb would also produce a lot of background radiation that would make it difficult to isolate the signals from the neutrinos. So Cowan and Reines changed their plans. Instead, they set up their detector in South Carolina next to a nuclear reactor. While the reactor produced neutrinos much more slowly than a bomb, the detector eventually picked up enough signals to confirm the existence of neutrinos. Pauli bought Baade a case of champagne to celebrate the discovery.

3. ______________________

Scientists had detected the undetectable particle. But there was a lot left to learn about it. In the 1960s, astrophysicists Raymond Davis and John Bahcall measured neutrinos coming from the sun with an experiment installed in Homestake Gold Mine in South Dakota. They detected only a third as many of the particles as they expected.

In the 90s, researchers at the Sudbury Neutrino Observatory in Canada and the Super-K experiment in Japan determined the cause of the missing neutrinos. The neutrino could “oscillate,” or shift between the three different types or “flavors”: electron neutrinos, muon neutrinos and tau neutrinos. Oscillation implies mass, so the discovery also let them know that neutrinos were not massless like they had thought.

Scientists had worked out theories about how neutrinos should oscillate, but those theories were put to the test in an experiment at Los Alamos called the Liquid Scintillator Neutrino Detector. LSND studied a beam of neutrinos — specifically, muon antineutrinos – to see how many of them oscillated to a different type over a short distance. Its results indicated more of them than anticipated had transformed into electron antineutrinos.

Scientists wondered: Could this elevated number of oscillations point to the influence of an even more elusive ghost particle? One that did not even interact through the weak force? Was it time to bet another case of champagne? In 2002, a similar experiment at Fermi National Accelerator Laboratory, named after Enrico Fermi, followed up. The MiniBooNE experiment operated at a different energy level and used a different experimental methodology than LSND; it recorded an excess in electron neutrinos as well. The results could possibly be accounted for if neutrinos were oscillating in strange ways – say, to more than three flavors. Because it would interact even less strongly with matter, scientists called the hypothetical missing neutrino flavor a "sterile" neutrino. There doesn't have to be just one type of sterile neutrino, says Harvard physicist Carlos Argüelles-Delgado. In the Standard Model of physics, for example, many particles and phenomena come in sets of three; maybe the sterile neutrinos do, too.

4. ________________

Argüelles-Delgado works on the IceCube experiment. Run by the University of Wisconsin and based in Antarctica, IceCube looks at neutrinos emitted from the sun or other astronomical phenomena, such as supernovae. Although sterile neutrinos aren't its focus, IceCube is one of several experiments offering input into the current search. So far IceCube has mostly just tightened constraints around what sterile neutrinos could be, Argüelles-Delgado says. "IceCube has not found any conclusive evidence of oscillations that are compatible with MiniBooNE," they say. "And we have found no conclusive evidence for a sterile neutrino. However, we have found hints of sterile neutrinos… We have found something that hints towards the right direction."

Another experiment that has provided valuable information to the search is MINOS, which from 2005 to 2012 studied a beam of neutrinos produced at Fermilab, sampling the particles both close to the origin of the beam and far from it in a mine in Minnesota. Its successor, MINOS+, collected data with a neutrino beam from 2013 to 2016. The experiments did not find anything that might suggest the existence of sterile neutrinos. With LSND and MiniBooNE seeing different results than IceCube and MINOS/MINOS+, Fermilab particle physicist Pedro Machado says it's nearly impossible to find cohesive evidence for sterile neutrinos. Also contributing to the conversation are a group of experiments that harken back to the first detection of neutrinos: reactor experiments such as Daya Bay in China, Double Chooz in France and RENO in Korea.

To date, they haven't found any reliable evidence to back up MiniBooNE or LSND, says Virginia Tech physicist Patrick Huber. In fact, Daya Bay, in a joint result with MINOS+, set stringent limits on sterile neutrinos. But the reactor experiments have been involved in their own conflict between theory and experimental results. In 2011, a group of theorists recalculated the expected number of electron antineutrinos that reactor experiments should have seen. They found that their prediction did not match the measurement. Since the discovery of the possible anomaly, researchers at Daya Bay, as well as theorists and other experimentalists, have continued working on their models and studying the decay processes that produce these antineutrinos.

5. ____________________

All of these different experiments offer input into the question of sterile neutrinos, but they offer it at different angles—using different methods and examining different sources of neutrinos. In the near future, scientists may get answers from experiments that try to match the perspectives of the original instigators of the sterile neutrino debate.

At the Japan Proton Accelerator Research Complex, an experiment called JSNS^2 plans to check the LSND observation. "We aim to confirm or defeat the existence of a sterile neutrino with the same experiment as LSND," says Takasumi Maruyama, a J-PARC researcher on JSNS^2. "There are lots of experiments, but we have to understand what's going on with the same neutrino source and same neutrino interaction. “So, 20 years after the LSND results, I think it’s a nice time to follow up on the LSND experiment.”

At Fermilab, an experiment called MicroBooNE aims to reproduce MiniBooNE’s measurements in more detail. Researchers expect initial results later this year. MicroBooNE also is a part of a larger experiment involving a series of three detectors known as the Short Baseline Neutrino Program at Fermilab. The three detectors will paint a detailed picture of neutrino behavior by examining oscillations at three different distances from the source of a neutrino beam. The ICARUS detector, which is the farthest from the source, will start collecting physics data this fall. Construction of the Short Baseline Near Detector, which is the closest to the source, is underway.

Huber says he imagines sterile neutrinos will remain hidden, possibly until even more precise, future detectors can be designed and built. It could be that they will never be found, either because they don’t exist or because Pauli’s predicted particle has an undetectable side to it after all. Argüelles-Delgado says that, whether or not upcoming experiments are able to find sterile neutrinos, science will benefit from the search. “In particle physics when there are hints, you have to pursue those hints,” they say, “because some hints will end up being challenges that just enable you to improve your detector technology and techniques—and other hints will do that and also let you discover new physics. So, you always win.”

Taken from https://www.symmetrymagazine.org/article/the-search-for-the-sterile-neutrino?language_content_entity=und

Text F

DINGO THERMAL NEUTRON

1. Critical Importance of Dingo

Dingo is presently the only thermal neutron imaging beamline available in Australia, and as such, is of critical importance to Australian researchers in a wide range of disciplines. Due to the high demand for access to Dingo, it is imperative that experiments on Dingo be optimised to make efficient use of time allocation. Analytical optimisation of experimental design is difficult due to the complexity of the beam and its surrounding environment — in particular, the neutron beam spectrum, field shape, the presence of a gamma component to the field, and the effects of the composition of the room in which the beam emerges.

2.____________________

A more practical approach would be to use a Monte Carlo simulation model of the beamline, which could then be used to evaluate a proposed experimental configuration. This "digital twin" would enable the parameters of the experiment to be explored in the simulation to determine the best beamline configuration and exposure intervals to maximise the likelihood of obtaining the desired results, to validate proposed dosimetric and spectrum measurement sensors, instruments and protocols and to estimate post-experiment activity levels in the experimental materials. It would also enable probing phenomena that are challenging or impossible to observe otherwise, such as prompt gamma emission or the decay of very short half-life isotopes. Such a model would therefore be a valuable tool for both users and beamline scientists.

3.____________________

This is the first Monte Carlo model of the Dingo beamline and to our best knowledge, the first high-resolution CAD-based Monte Carlo model of a reactor-based thermal neutron beamline in general. However, similar models have been created in the past for other neutron beamlines, for instance the TRIUMF accelerator-based thermal neutron facility in Canada, modelled in MCPNX10; the cold neutron facility (ICON) at the Swiss Spallation Neutron Source (SINQ), also modelled in MCPNX11, neutron imaging facility at TRIGA reactor in Morocco, modelled using Geant4[12] and the high energy neutron irradiation facility at the China Spallation Neutron Source, modelled in MCNPX[13].

4. ________________

These models were designed for a range of different purposes, such as the characterisation of the high-energy neutron field, coupling of the MCNPX and McStas packages, neutron beamline design or the generation of preliminary data for the physical experiments. In this work, a validated Monte Carlo model of the ACNS Dingo beamline has been developed and used to predict the in-beam neutron spectra at the sample stage position. The model can either be used directly or the neutron field that it generates can be provided to users in the form of a phase-space file, reducing the computational workload. The next stage of this work will include a comparison of simulation and experimental gamma spectra in the out-of-beam region, which will be used to indirectly validate the in-beam gamma spectrum.

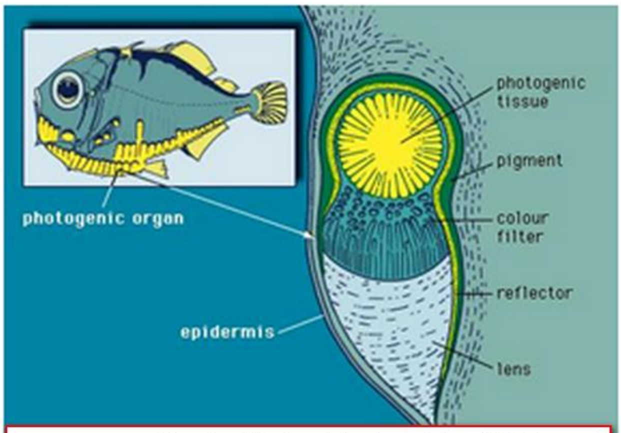
Taken from https://www.nature.com/articles/s41598-023-44035-4

UNIT 2. BIOPHYSICS

TEXT A

BIOLUMINESCENCE

(1) Bioluminescence, emission of light by an organism or by a laboratory biochemical system derived from an organism. It could be the ghostly glow of bacteria on decaying meat or fish, the shimmering radiance of protozoans in tropical seas, or the flickering signals of fireflies. The phenomenon occurs sporadically in a wide range of protists and animals, from bacteria and fungi to insects, marine invertebrates, and fish, but it is not known to exist naturally in true plants or amphibians, reptiles, birds, or mammals. Bioluminescence results from a chemical reaction (chemiluminescence) in which the conversion of chemical energy to radiant energy is direct and virtually 100 per cent efficient; i.e., very little heat is given off in the process. For that reason, the emission is called cold light or luminescence.



Taken from https://www.britannica.com/science/bioluminescence

The role of bioluminescence in behaviour

(2) Light production appears to be associated with the protection and survival of a species. That is quite clear in certain squids, which secrete a luminous cloud to confuse an enemy and make an escape, and in many deep-sea fishes who dangle luminous lures to attract prey or who show light organs to disguise their form from enemies, frighten predators, or simply light the way in the darkness of the ocean deeps. The survival value of bioluminescence is indisputable for many organisms that use their flashes as species-recognition and mating signals.

(3) In Photinus pyralis, a common North American firefly, the male flashes spontaneously while in flight, emitting on average a 0.3-second flash every 5.5 seconds if the temperature is 25 °C (77 °F). The females watch from the ground and wait for a male to flash. Upon seeing a flash, a female flashes a response after an interval of about

2 seconds. It is that response that attracts the male. The female is unable to identify a male by his flashing. Thus, it is the male that recognizes the correct signal – i.e., the interval between flashes – and seeks out the female. The interval between the male's signal and the female's response, therefore, is crucial. Similar specific recognition codes are used by many species of fireflies. Other fireflies possibly rely on colour differences in the light signals between sexes.

(4) Lantern fishes and hatchet fishes, along with many other deep-sea organisms, possess distinct arrangements of light organs on the body that may serve as species- and sex-recognition patterns. The light organs, or photophores, of many deep-sea fishes are placed on the ventral and lateral surfaces of the body, and the light is emitted downward and outward. Such an arrangement is believed to allow the light of the photophores to be used to match the intensity of sunlight penetrating from above, thus concealing the fish's own shadow from a predator below. Some lantern fishes possess, in addition, a large nasal organ; others have a patch of luminous tissue in the tail region. In deep-sea anglerfishes, the first dorsal spine is turned forward into an elongated rod, from the end of which dangles a luminous organ. When an unsuspecting prey approaches the luminous lure, it is engulfed in the fish's large jaw.

The role of bioluminescence in metabolism

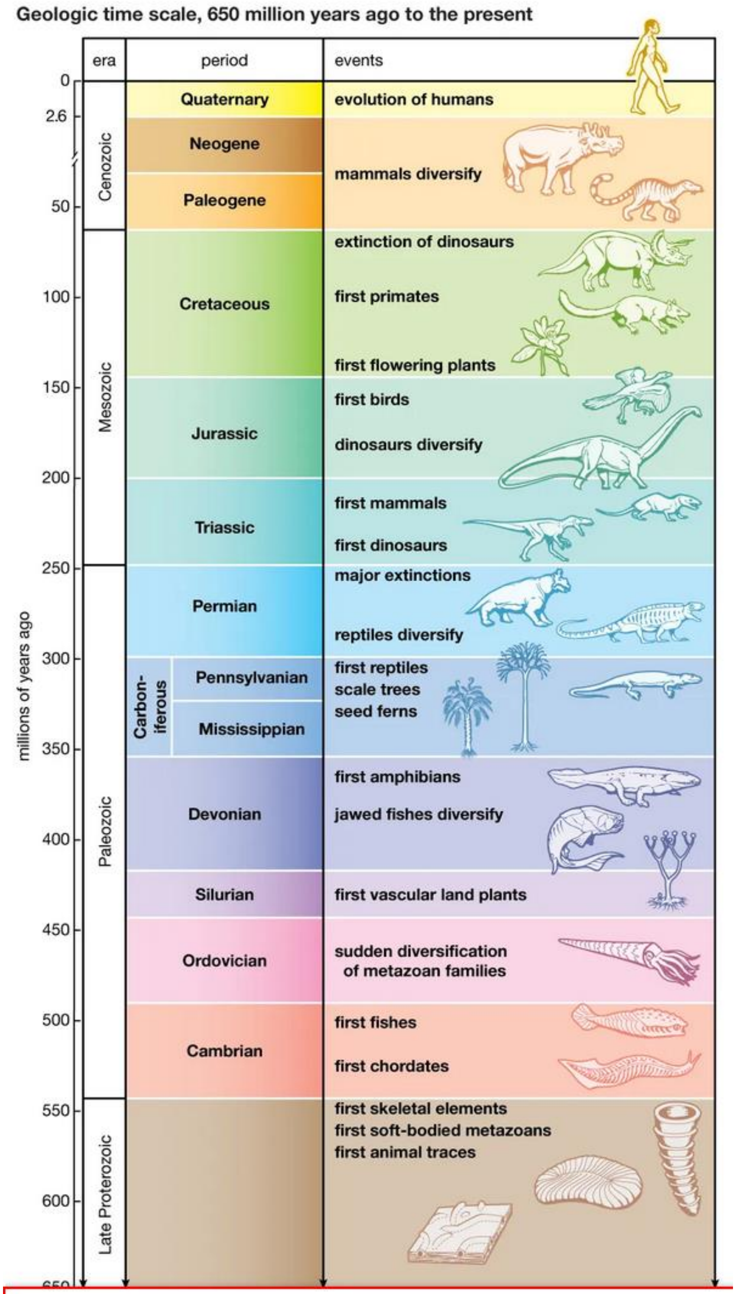
(5) The functional role of bioluminescence in lower organisms such as bacteria, dinoflagellates, and fungi is difficult to discern. Partly because the glow of luminous bacteria is extinguished when oxygen is removed, it has been suggested that the bioluminescent reaction was originally used to remove oxygen toxic to primitive types of bacteria that developed when oxygen was absent or very rare in Earth's atmosphere. The metabolic reaction that combines oxygen with a reducing substance (luciferin) liberates sufficient energy to excite a molecule in the organism to emit visible radiation. Most of those luminous primitive organisms subsequently developed systems of using oxygen, but they have retained the luminescent capability as parts of related metabolic pathways or for some survival value that luminescence may confer on the organism.

Taken from https://www.britannica.com/science/bioluminescence

TEXT B

MOLECULAR BIOLOGY

(1) The field of molecular biology provides the most detailed and convincing evidence available for biological evolution. In its unveiling of the nature of DNA and the workings of organisms at the level of enzymes and other protein molecules, it has shown that these molecules hold information about an organism's ancestry. This has made it possible to reconstruct evolutionary events that were previously unknown and to confirm and adjust the view of events already known. The precision with which these events can be reconstructed is one reason the evidence from molecular biology is so compelling. Another reason is that molecular evolution has shown all living organisms, from bacteria to humans, to be related by descent from common ancestors.



Taken from https://www.britannica.com/science/evolution-scientific-theory#ref176461

(2) A remarkable uniformity exists in the molecular components of organisms like the components as well as how they are assembled and used. In all bacteria, plants, animals, and humans, the DNA comprises a different sequence of the same four component nucleotides, and all the various proteins are synthesized from different combinations and sequences of the same 20 amino acids, although several hundred other amino acids do exist. The genetic code by which the

information contained in the DNA of the cell nucleus is passed on to proteins is virtually everywhere the same. Similar metabolic pathways – sequences of biochemical reactions (see metabolism) – are used by the most diverse organisms to produce energy and to make up the cell components.

(3) This unity reveals the genetic continuity and common ancestry of all organisms. There is no other rational way to account for their molecular uniformity when numerous alternative structures are equally likely. The genetic code serves as an example. Each particular sequence of three nucleotides in the nuclear DNA acts as a pattern for the production of exactly the same amino acid in all organisms. This is no more necessary than it is for a language to use a particular combination of letters to represent a particular object. If it is found that certain sequences of letters—planet, tree, woman – are used with identical meanings in a number of different books, one can be sure that the languages used in those books are of common origin.

(4) Genes and proteins are long molecules that contain information in the sequence of their components in much the same way as sentences of the English language contain information in the sequence of their letters and words. The sequences that make up the genes are passed on from parents to offspring and are identical except for occasional changes introduced by mutations. As an illustration, one may assume that two books are being compared. Both books are 200 pages long and contain the same number of chapters. Closer examination reveals that the two books are identical page for page and word for word, except that an occasional word – say, one in 100 – is different. The two books cannot have been written independently; either one has been copied from the other, or both have been copied, directly or indirectly, from the same original book. Similarly, if each component nucleotide of DNA is represented by one letter, the complete sequence of nucleotides in the DNA of a higher organism would require several hundred books of hundreds of pages, with several thousand letters on each page. When the "pages" (or sequences of nucleotides) in these "books" (organisms) are examined one by one, the correspondence in the "letters" (nucleotides) gives unmistakable evidence of common origin.

(5) The two arguments presented above are based on different grounds, although both attest to evolution. Using the alphabet analogy, the first argument says that languages that use the same dictionary – the same genetic code and the same 20 amino acids – cannot be of independent origin. The second argument, concerning similarity in the sequence of nucleotides in the DNA (and thus the sequence of amino acids in the proteins), says that books with very similar texts cannot be of independent origin.

(6) The evidence of evolution revealed by molecular biology goes even further. The degree of similarity in the sequence of nucleotides or of amino acids can be precisely quantified. For example, in humans and chimpanzees, the protein molecule called cytochrome c, which serves a vital function in respiration within cells, consists of the same 104 amino acids in exactly the same order. It differs, however, from the cytochrome c of rhesus monkeys by 1 amino acid, from that of horses by 11 additional amino acids, and from that of tuna by 21 additional amino acids. The degree of similarity reflects the recency of common ancestry. Thus, the inferences from comparative anatomy and other disciplines concerning evolutionary history can be tested in molecular studies of DNA and proteins by examining their sequences of nucleotides and amino acids. (See below DNA and protein as informational macromolecules.)

(7) The authority of this kind of test is overwhelming; each of the thousands of genes and thousands of proteins contained in an organism provides an independent test of that organism's evolutionary history. Not all possible tests have been performed, but many hundreds have been done, and not one has given evidence contrary to evolution. There is probably no other notion in any field of science that has been as extensively tested and as thoroughly corroborated as the evolutionary origin of living organisms.

Taken from https://www.britannica.com/science/evolution-scientific-theory/Biogeography

UNIT 3. OPTICS AND HOLOGRAPHY

Text A

Dennis Gabor, a Pioneer in Holography

Dennis Gabor (1900-1979) was born in Budapest, Hungary. His lifelong love of physics started at age 15. He was especially influenced by Gabriel Lippmann's method of colour photography. Gabor and his brother built a small laboratory in their home, where they repeated popular experiments of the day. When Gabor was ready for college, he chose to study engineering rather than physics because physics was not yet a profession in Hungary. Although Gabor studied at the Technische Hochschule Berlin, he often travelled to the University of Berlin to hear lectures by Einstein, Planck, Nernst, and von Laue. His doctoral work centred on the development of one of the first high-speed, cathode ray oscillographs. In the course of this work, Gabor made the first iron-shrouded, magnetic electron lens. In 1927 Gabor joined Siemens & Halske AG, where he made a high-pressure quartz mercury lamp with superheated vapour and closed with a molybdenum tape seal. After its introduction, the component became integral to millions of streetlamps.

When Hitler came to power in 1933, Gabor left Germany and after a short time in Hungary travelled to England. He found a job with the British Thomson-Houston Co., where he remained until the end of 1948. During that last year at Thomson-Houston, Gabor carried out basic experiments in holography, which at the time was termed “wavefront reconstruction.” He began these experiments with the goal of creating an electron microscope able to resolve atomic lattices and image single atoms. However, as Gabor himself once stated, “We started 20 years too early.” With the advent of a coherent light source, the laser, holography became practical. In 1962 Emmett Leith and Juris Upatnieks at the University of Michigan and Yuri Denisyuk in the Soviet Union created holograms based on Gabor’s early work. Gabor had coined the term hologram from the Greek words holos, meaning “whole,” and gramma, meaning “message.” Gabor’s technique to reconstruct a three-dimensional image from phase and magnitude information also led to advances in signal processing. The Gabor

Transform is one of the essential ideas in wavelet theory used for digital signal processing.

In 1949, Gabor joined the Imperial College of Science & Technology in London, first as a reader in electronics. He later became a professor of applied electron physics. Over the next 17 years, Gabor and his graduate students and colleagues attacked many problems including the elucidation of Langmuir's Paradox, the inexplicably intense electron interaction in low- pressure mercury arcs. They also made a Wilson cloud chamber that allowed them to measure the velocity of particles by introducing a high-frequency critical field. Other research involved a holographic microscope, an electron-velocity spectroscope, an analogue computer, a flat, thin colour television tube, and a new type of thermionic converter. The group also developed theoretical work for communications, plasmas, and magnetrons. As a scientist, Gabor believed that a serious mismatch had developed between technology and social institutions and that inventive minds ought to consider social inventions as their first priority. He expressed this conviction in three books, *Inventing the Future*, *Innovations,* and *The Mature Society*. Gabor's career was marked by many honours including the Nobel Prize for Physics, the IEEE Medal of Honour, the French Physical Society's Prix Holweck, Commander of the Order of the British Empire, the Franklin Institute's Michelson Medal, and the Royal Society's Rumford Medal.

Taken from https://www.optica.org/en-us/history/biographies/bios/dennis-gabor/

Text B

Hologram Technology – Myths and Facts about it

Holographic imaging and holography are some of the hottest areas of technology, due to the fact that holograms are unique, extremely precise, and can be applied to a wide variety of industries and applications. However, there are still many misconceptions about holography and its uses. Below there is a list of five common myths.

Myth 1. Holograms are made of lines and dots.

Holograms are made up of much more than just lines and dots. By definition, a hologram is a two-dimensional image that is created using a particular scanning technique. The scanning technique can be a flat one that uses mirrors to create the image or it can be a polarizing lens that uses certain filters to alter the angle and intensity of light that scans the surface being scanned.

Myth 2. Holograms are only useful for advertising

Holographic advertising and holograms, in general, are highly effective and can be used for a wide variety of advertising and marketing purposes. Both small and large-scale companies can take advantage of holographic images to develop a sense of brand loyalty, create brand awareness and promote sales. They can even be used to create images to remind customers of services or products. There are no limits to what can be done with holographic images.

Myth 3. Holograms are too expensive to be worth the effort of developing them

Since holographic technology is available for less than a couple hundred US dollars currently, you can have your hologram prototype made at a fraction of the cost. With new and innovative ideas coming along every few months, and with holographic chips becoming more widely understood and appreciated by businesses of all sizes, it’s not surprising that holographic prototypes would soon be commonplace in most businesses around the world. While the cost of developing holograms was expensive initially, the prices have been coming down steadily now, and holographic display screens are much more affordable than they were just a few years ago. In addition, it’s a lot easier to manufacture holograms these days, which is something that most inventors might want to consider.

Myth 4. Holograms don’t look like anything

With the right software, a hologram can be designed to look just like any other image, including those that mimic objects or images found in magazines, books, and websites. When the hologram is developed, its image is created in three dimensions.

Myth 5. Holograms don’t exist

This, again, is simply a misconception. While it would be impossible to manufacture a hologram, there are ways to create a unique hologram on a flat surface. Thus, while there are no ‘true’ holograms, there are truly interesting, unique holograms out there.

Adapted from https://www.businesspally.com/holography-technology/

UNIT 4. NANOTECHNOLOGIES

Text A

Nanotechnology in Food Processing

(1) The nanostructured food ingredients are being developed with the claims that they offer improved taste, texture, and consistency. Nanotechnology increasing the shelf-life of different kinds of food materials and also help brought down the extent of wastage of food due to microbial infestation. Nowadays nanocarriers are being utilized as delivery systems to carry food additives in food products without disturbing their basic morphology. Particle size may directly affect the delivery of any bioactive compound to various sites within the body as it was noticed that in some cell lines, only submicron nanoparticles can be absorbed efficiently but not the larger size micro-particles.

(2) An ideal delivery system is supposed to have following properties: (i) able to deliver the active compound precisely at the target place (ii) ensure availability at a target time and specific rate, and (iii) efficient to maintain active compounds at suitable levels for long periods of time (in storage condition). Nanotechnology being applied in the formation of encapsulation, emulsions, biopolymer matrices, simple solutions, and association colloids offers efficient delivery systems with all the above-mentioned qualities. Nano polymers are trying to replace conventional materials in food packaging. Nanosensors can be used to prove the presence of contaminants, mycotoxins, and microorganisms in food.

(3) Nanoparticles have better properties for encapsulation and release efficiency than traditional encapsulation systems. Nanoencapsulations mask odors or tastes, control interactions of active ingredients with the food matrix, control the release of the active agents, ensure availability at a target time and specific rate, and protect them from moisture, heat, chemical, or biological degradation during processing, storage, and utilization, and also exhibit compatibility with other compounds in the system. Moreover, these delivery systems possess the ability to penetrate deeply into tissues

due to their smaller size and thus allow efficient delivery of active compounds to target sites in the body. Various synthetic and natural polymer-based encapsulating delivery systems have been elaborated for the improved bioavailability and preservation of the active food components.

(4) Further, the importance of nanotechnology in food processing can be evaluated by considering its role in the improvement of food products in terms of (i) food texture, (ii) food appearance, (iii) food taste, (iv) nutritional value of the food, and (v) food shelf-life. It is a matter of fact that surprisingly nanotechnology not only touches all the above-mentioned aspects but has also brought about significant alterations in food products providing them novel qualities.

Taken from https://www.frontiersin.org/articles/10.3389/fmicb.2017.01501/full

Text B

Nanotechnology in Architectural Projects

(1) The architecture and production industry accounts for around half of the world's power consumption and a quarter of the planet's greenhouse gas emissions. Globally approved and extensively used construction practices have direct adverse effects on the environment, excessive resource depletion, antagonizing public health issues, and environmental degradation.

(2) Nanotechnology, which involves manipulating matter at the atomic and molecular level to produce materials with remarkably varied and novel properties, is a quickly developing field of study with enormous potential in a wide range of industries, including construction, electronics, healthcare, and building materials. It has the potential to completely transform several fields of research, development, and industrial applications.

(3) Beyond nanoscience, nanotechnology attempts to use the properties of innovative nanomaterials to enhance a wide range of applications.

(4) Concrete is the most commonly used building material in the construction industry. As concrete is utilized in the structure of buildings, much interest is placed in refining its qualities. By incorporating substances like carbon nanotubes and nano-silica, physical properties of structures such as strength, conductive properties, and durability can be improved.

(5) Nanotechnology can provide a clever remedy for concrete product corrosion by creating coatings that respond to external factors in a way that can either be corrected or avoided. Recent studies on the application of versatile materials, such as carbon nanotubes and nanoparticles, demonstrate that these elements increase the compressive strength and flexibility of cement mortar samples.

(6) The potential of nanostructures to repair damaged structural surfaces on their own is extremely advantageous to the construction sector. Nanosensors are used in constructions to aid in the prediction of current problems.

(7) Microcapsules rupture releases a healing ingredient that gradually repairs the damaged concrete mix. The healing ingredient fills the fracture by capillary action. Consequent polymerization helps fill the cracks.

(8) The ability to absorb carbon pollution into the environment has been developed using nanotechnology. Energy may be produced and stored using nanotechnology both in and out of these structures, making it possible to produce new power sources and enhance the amount of currently available energy.

(9) Nanotechnology can also be used to create extremely thin layers with cleaning and color-changing capabilities to cut down on pollution and energy use.

(10) The biggest problem with using nanotechnology in architecture and building is how they are currently being developed and adapted owing to economic factors. With increased commercial use, exposure to these nanomaterials also increases, which could have negative consequences.

(11) Further progress can be made in scientific endeavors by governments, research and development organizations, manufacturers, and other businesses by collaborating on several levels to implement the new nanotechnological applications, especially in architecture.

Taken from https://www.azonano.com/news.aspx?newsID=39469

UNIT 5. ACOUSTICS

Text A

The Nature of Music

(1) Music is indeed remarkable in its power over all humankind, and perhaps for that very reason, no human culture on earth has ever lived without it. From discoveries made in France and Slovenia even Neanderthal man, as long as 53,000 years ago, had developed surprisingly sophisticated, sweet-sounding flutes carved from animal bones. It is perhaps then, no accident that music should strike such a chord with the limbic system – an ancient part of our brain, evolutionarily speaking, and one that we share with much of the animal kingdom. Some researchers even propose that music came into this world long before the human race ever did. For example, the fact that whale and human music have so much in common even though our evolutionary paths have not intersected for nearly 60 million years suggests that music may predate humans. They assert that rather than being the inventors of music, we are latecomers to the musical scene.

(2) Humpback whale composers employ many of the same tricks that human songwriters do. In addition to using similar rhythms, humpbacks keep musical phrases to a few seconds, creating themes out of several phrases before singing the next one. Whale songs in general are no longer than symphony movements, perhaps because they have a similar attention span. Even though they can sing over a range of seven octaves, the whales typically sing in key, spreading adjacent notes no farther apart than a scale. *They* mix percussive and pure tones in pretty much the same ratios as human composers – and follow their ABA form, in which a theme is presented, elaborated on, and then revisited in a slightly modified form. Perhaps most amazing, humpback whale songs include repeating refrains that rhyme. It has been suggested that whales might use rhymes for exactly the same reasons that we do: as devices to help them remember. Whale songs can also be rather catchy. When a few humpbacks from the Indian Ocean strayed into the Pacific, some of the whales they met there quickly changed their tunes – singing the new whales' songs within three short years. Some scientists are even tempted to speculate that a universal music awaits discovery.

Text B

A Capsule History of Acoustics

(1) Of the five senses that we possess, hearing probably ranks second only to sight in regular usage. It is therefore with little wonder that human interest in acoustics would date to prehistoric times. Sound effects entailing loud clangorous noises were used to terrorize enemies during heated battles; yet the gentler aspects of human nature became manifest through the evolution of music during primeval times, when it was discovered that the plucking of bow strings and the pounding of animal skins stretched taut made for rather interesting and pleasurable listening.

(2) Life in prehistoric society was fraught with emotion, just as in the present time, so music became a medium of expression. Speech enhanced by musical inflection became a song. Body motion following the rhythm of accompanying music evolved into dance. Animal horns were fashioned into musical instruments (the Bible described the ancient Israelites' use of *shofarim*, made from horns of rams or gazelles, to sound alarms for the purpose of rousing warriors to battle). Ancient shepherds amused themselves during their lonely vigils playing on pipes and reeds, the precursors of modern woodwinds.

(3) With sound as a major factor affecting human lives, it was only natural for interest in the science of sound, or acoustics, to emerge. In the twenty-seventh century BCE, Lin-lun, a minister of the Yellow Emperor Huangundi, was commissioned to establish a standard pitch for music. He cut a bamboo stem between the nodes to make his fundamental note, resulting in the "Huang-Zhong pipe"; the other notes took their place in a series of twelve standard pitch pipes. He also took on the task of casting twelve bells in order to harmonize the five notes, so as to enable the composing of regal music for royalty. Archeological studies of the unearthed musical instruments attested to the high level of instrument design and the art of metallurgy in ancient China. At approximately 2000 BCE, another Chinese, the philosopher Fohi, attempted to establish a relationship between the pitch of a sound and the five elements: earth, water, air, fire, and wind.

(4) The ancient Hindus systematized music by subdividing the octave into 22 steps, with a large whole tone containing four steps, a small tone assigned three, and a halftone containing two such steps. The Arabs carried matters further by partitioning the octave into 17 divisions. However, the ancient Greeks developed musical concepts similar to those of the modern Western world. Three tonal genders – the diatonic, the chromatic, and the enharmonic – were attributed to the gods.

(5) Observation of water waves may have influenced the ancient Greeks to surmise that sound is an oscillating perturbation emanating from a source over large distances of propagation. It cannot have failed to attract notice that the vibrations of plucked strings of a lute can be seen as well as felt.

(6) The honor of being the earliest acoustician probably falls to the Greek philosopher Chrysippus (ca. 240 BCE), the Roman architect-engineer Vitruvius (also known as Marcus Vitruvius Pollio, ca. 25 BCE), and the Roman philosopher Severinus Boethius (480–524). Aristotle (384–322 BCE) stated in a rather pedantic fashion that air motion is generated by a source "thrusting forward in like movement the adjoining air, so that sound travels unaltered in quality as far as the disturbance of the air manages to reach." Pythagoras (570–497 BCE) observed that "air motion generated by a vibrating body sounding a single musical note is also vibratory and of the same frequency as the body;" and it was he who successfully applied mathematics to the musical consonances described as the octave, the fifth and the fourth, and established the inverse proportionality of the length of a vibrating string with its pitch.

Taken from https://www.arauacustica.com/files/publicaciones_relacionados/pdf_esp_198.pdf

APPENDIX 2. MINI-DICTIONARY

UNIT 1. PARTICLE PHYSICS

incarnation	втілення, уособлення
impose	нав’язати
menagerie	звіринець
irreducible	мінімальний, нескоротний
rival	суперник, конкурент
emerge	з’ясовуватися
cautious	обережний
exciting	схвильований
assuming that	за умови, що
fork out	розщедритися
fermion	ферміон
impressive	вражаючий
consensus	згода, консенсус
prevail	переважати
flaw	вада, помилка
hubris	зарозумілість
mere	простий
constituent	компонент, складова частина
quark	кварк
flavor	смак, присмак, родзинка

charm	шарм, чарівність
thus	таким чином
approximation	наближення
constituents	складові
intruder	порушник
stepping-stone	сходинка
accelerator	прискорювач

UNIT 2. BIOPHYSICS

biophysics	біофізика
biological system	біологічна система
apply	застосувувати
molecule	молекула
plant cell	рослинна клітина
circulation	кругообіг
immune system	імунна система
biofuel	біопаливо
vibrant scientific field	активна наукова сфера
pharmacology	фармакологія
materials sciences	матеріалознавство
physical scientists	вчені-фізики
life scientists	вчені-біологи
ecosystem	екосистема
kidney dialysis	діаліз нирок
radiation therapy	радіотерапія
uniquely trained	унікально навчений
be able to tackle	вміти впоратися
a wide array of topics	широкий спектр тем
range from … to	діапазон від … до
renewable energy source	відновлюване джерело енергії
cutting-edge technology	передові технології
a blueprint for life	план життя
life-saving treatment	лікування, що рятує життя
fluorescent tag	флуоресцентна мітка
internal transit system	система внутрішньої передачі
environmental biophysics	екологічна біофізика

stratosphere	стратосфера
deep ocean vent	глибоководне жерло океану
microbial community	мікробне співіснування
cardiac defibrillators	серцеві дефібрилятори
pacemaker	кардіостимулятор

UNIT 3. OPTICS AND HOLOGRAPHY

misrepresentation	хибне уявлення
three-dimensional	тривимірний
interference	інтерференція; втручання,
light beam	світловий промінь
reflect	відбивати, віддзеркалювати
precisely	точно
interaction	взаємодія
reference beam	опорний промінь
capture	зберегти, зафіксувати, відобразити
investigation	дослідження, розслідування
imprinted	відображений
transmitted	переданий
distinct	окремий, відмінний
perception	сприйняття
dispersed	розсіяний
augmented reality	доповнена реальність
replica	копія
incorporating	що включає
exceed	перевищувати
sophisticated	витончений

UNIT 4. NANOTECHNOLOGIES

to crawl	повзати, розповзатись
flecks of gold chloride	крупинки хлориду золота
an armored exoskeleton	броньований екзоскелет
arranged by the sequence	розташоваий у послідовності
ambitious advancements	амбітні досягнення
medium	середовище
equated	прирівняний
build from the ground up	побудувати з нуля
dreamt up	котрий приснився
semiconductors	напівпровідники
auto-repair mid flight	авторемонт у польоті
an aqueous environment	водне середовище
a handful of encounters	кілька зустрічей\випадків
to tailor the core structures	розробити основні структури
unwittingly	мимовільно
adhesives	клеї
a miniaturization	мініатюризація
increased malleability	підвищена пластичність
direct hand in	пряма задача
durable	міцний, стійкий

standout marker	видатний маркер
robust	надійний, міцний
to tackle climate change	боротися зі зміною клімату
conductive	провідний
embedded into	вбудований в
life-sized counterparts	екземпляри в натуральну величину
conversion rates	коефіцієнти конверсії
stained glass windows	вітражі
to attribute	приписувати
in its adolescence	у своєму молодому віці

UNIT 5. ACOUSTICS

a propagation	поширення
a dwelling	житло
to permeate	проникати
considerably	значно
to draw up	складати, створювати
to adjoin	прилягати, з’єднувати
in conjunction with	в поєднанні з
sensation	сприйняття, відчуття
fluctuations	коливання
longitudinal waves	поздовжні хвилі
ripples	брижі (невеликі, неправильної форми хвилі)
to radiate	виходити
a pond	ставок
density	щільність, густота
velocity	швидкість
pressure	тиск
distinction	винятковість
transversal waves	поперечні хвилі
to constitute	складати, являти собою
throughout	через
net	чистий, без домішок
via	за допомогою
an insulation	ізоляція
plumbing	сантехніка

APPENDIX 3. GRAMMAR REFERENCE

Articles

There are four articles in English:

1. **a (the indefinite article);**
2. **an (the indefinite article);**
3. **the (the definite article);**
4. **Ø (the invisible zero article).**

The articles are divided into two major categories: the indefinite articles (a, an, and Ø) for indefinite nouns and the definite article (the) for definite nouns.

Part 1. A(n) and Ø (the Zero Article)

To use articles correctly it is important to remember that *a(n)* is related to *one* in choosing between the article *a(n)* and *Ø.*

a microprocessor

(Ø) quality

(Ø) research

an idea

a solid

(Ø) gases

a glass

Using articles with count and noncount nouns one should remember that *a(n)* means any single item. Therefore, *a(n)* cannot be used neither with a noncount noun because it means a quantity, nor with a plural count noun because *plural* means *more than one*.

Article	Type of Noun	Example
a(n)	singular count	a lab
Ø	noncount	(Ø) air

Ø	plural count	(Ø) gases

Part 2. A and A(n)

To use articles correctly one should remember that the sound of the following word controls the choice of *a* or *an*.

human scale *a human scale*

hour *an hour*

movie *a one-hour movie*

measurement *an objective measurement*

In case of an acronym (a name which consists of letters), the sound of the first letter defines the choice of *a* or *an*.

a BTU (British thermal unit)

an LED (light-emitting diode)

Word order is important: an article is always before an adjective, and the choice of *a* or *an* depends on the first sound of any word after the article.

Noun	***Adjective + Noun***	***Adverb+ Adjective + Noun***
a book	*an outstanding book*	*a truly outstanding book*
a lab	*an amazing lab*	*an absolutely amazing lab*
an element	*a rare element*	*an extremely rare element*

Part 3. Count and Noncount Nouns

Each count noun is a separate entity; therefore, count nouns can be counted. Count nouns can be singular (one item) or plural (two items or more).

Singular Count Noun: a glass, an hour

Plural Count Noun: Ø glasses, Ø hours

Noncount nouns cannot be counted because each noun is a material or form with no definite shape rather than a separate entity. Therefore, noncount nouns can be only singular and require the article Ø.

Noncount noun: Ø air; Ø plastic

To determine whether nouns are count or noncount, we should answer a question if they are separate entities. If they are, then we can count them and they can be plural like *glasses* or *elements*. If nouns are materials or forms with no definite shape, we cannot count them and they cannot be plural like *air* or *chemistry*.
Still, noncount nouns can be made countable. In case of solids and specific information we can use *a piece of* before nouns.

a piece of wood

a piece of advice

a piece of information

a piece of data

a piece of paper

In case of powders, liquids and gases we can use more specific words.

a grain of salt

a particle of sand

a molecule of water

a molecule of oxygen

a peck of dust

Powders, liquids and gases can be made countable by using containers or limits.

a teaspoon of salt

a crystal of sugar

a bottle of water

a jet of water

a tank of air

a blast of air

There is a group of noncount nouns which is called mass nouns as they represent count nouns.

Mass Noun (noncount)	***Individual Examples (plural count)***
Ø money	*Ø dollars, Ø pounds, Ø coins*
Ø equipment	*Ø test tubes, Ø thermometers*
Ø machinery	*Ø engines, Ø bikes, Øhelicopters*

Dual nouns may be both count and noncount, in each case they have a different meaning.

Noun (noncount)	***Noun (count)***
Ø iron (Fe, an element)	*an iron (an appliance for making clothes smooth)*
Ø glass (a clear, hard silicate)	*a glass (a container for a liquid)*
Ø rubber (material)	*a rubber (an object for removing traces of a pen or pencil)*

However, the count/noncount difference may be used to indicate either a general sense or a specific one.

Noun (noncount, general)	***Noun (count, specific)***
Ø metal	*metals*
Ø plastic	*plastics*
Ø infection	*infections*

Part 4. A(n) and One

The article *a(n)* may be used as the word *one*.

Our class meets four times a week (in one week).

She earns $38,000 a year (for one year).

However, there are cases when *a(n)* is not the same as *one*.

The researcher used a pipette. (He used an instrument called a pipette).

The researcher used one pipette. (He used just one, not two pipettes).

***A(n)* refers to any single item, while *one* means a limited number.**

(Master, 2004, p.2-10)

Part 5. Articles with Proper Nouns

Proper nouns are names or titles that refer to distinct people, places, or things. Proper names are used with the article *the* and *0*. Names require the *null* articles, but titles require *the*.

Category	***Name***	***Title***
People	*President Bush*	*the President of the U.S.*
	Mr. Blair	*the Prime Minister of England*
	Dr. Lau	*the Dean of the School of Engineering*
Countries	*Korea*	*the Republic of Korea*
	America	*the United States of America*
Cities	*Tokyo*	*the city of Tokyo*

Proper nouns require *the* if they refer to certain geographical features.

Category	***Name***
oceans	*the Atlantic Ocean*
rivers	*the Dnipro River*
canals	*the Panama Canal*

deserts	*the Sahara Desert*
forests	*the Black Forest*
islands	*the Philippines*
lakes	*the Great Lakes*
mountains	*the Carphathian Mountains*

Proper nouns require *the* if they refer to certain cultural institutions.

Category	***Name***
associations	*the American Medical Association (AMA)*
commissions	*the Nuclear Regulatory Commission (NRC)*
libraries	*the Boston Public Library*
museums	*the British Museum*

Proper nouns require the null article if they refer to certain geographical features.

Category	***Name***
areas	*Eastern Europe*
continents	*Asia*
valleys	*Desolation Valley*

Proper nouns require the null article if they refer to certain cultural features.

Category	***Name***
holidays	*Christmas*
parks	*Hyde Park*

streets	*Blake Street*

Proper nouns with the and Ø:

There are a few cultural institutions which occur with *the* or *Ø*. It is important to know that *Ø* is usually used when the proper noun phrase begins with a family name.

Category	***Example with the***	***Example with Ø***
buildings	*the World Trade Center*	*Wheeler Auditorium*
businesses	*the Shell Oil Company*	*Hewlett-Packard*
universities	*the University of Iowat*	*McGill University*

Part 6. Articles in Titles and Labels

Newspaper and magazine headlines, as well as titles and labels, use "telegraphic speech", which deletes function words including articles, prepositions and conjunctions.

Figure titles

(The) Solubility of carbon disulfide with methyl alcohol

(A) Longitudinal section of hair follicle

Map title

(The) Average rainfall and temperature (in degrees F.) of South America

Photo label

(The) Shedding of skin by red-bellied water snake

(The) Turbine-driven auxiliary oil pump

(A) Programmer using (a) template

There are no rules for article deletion in titles and labels. The first article or all articles may be deleted, but in some cases articles may be retained.

Part 7. Idiomatic structures with A(n) article

The phrases *a few* and *few* both indicate small quantities. Used with the article *a*, the phrase has a positive or neutral sense, while the *zero* article makes it negative. The word *only* is used with *a few*; the word *so* can occur with *few* and *little*.

The satellite camera took a few excellent shots of Jupiter's moon Io.

Only a few elements are liquids at room temperature.

A few atoms of plutonium in a human body is enough to trigger cancerous growth.

Few animals live at the polar icecap.

So few patients survived that the drug was banned.

Few people knew how difficult a problem the containment of a fusion plasma would be.

A little alcohol acts as a stimulant to the body.

There was so little water that the animals died.

The investigators knew that the reactor had leaked because a little radioactive water was found nearby.

The negative sense with the Ø article may produce an overall positive effect.

Few scientists have influenced scientific thinking like Einstein.

Little time was lost in getting the patient into surgery.

Part 8. A (fraction) of versus half

Most fractions use an of-phrase with the article a(n) or the number one.

a third of the population

a quarter of the population

an eighth of the population

Air pollution decreased in a quarter of the nation's cities.

Only the fraction half is commonly written without a.

half (of) the population

The life expectancy of a kangaroo is about half that of a cat.

Part 9. A(n) with *how, so, as, too* and *no less*

Such words as *how, so, as, too* and *no less attract an adjective and displace the article.*

The coil developed so high a voltage that the rods arced immediately.

Nuclear power is no less a problem than nuclear weaponry.

Few people knew how difficult a problem the containment of a fusion plasma would be.

Part 10. Adverbial *the*

Adverbial *the* is ised before comparatives to indicate degree or amount.

The sun's brightness makes it all the more difficult to study with an optical telescope.

Radiation in the damaged reactor vessel rendered it the harder to repair.

Adverbial *the* is ised to indicate a direct or an inverse relationship.

The faster a car moves, the more time it takes to stop.

The more oil we use, the less there will be for future generations.

The brighter the light, the smaller the lens aperture.

Such a comparison does not need a verb.

(Master, 2004, p.243-249)

Part 11. The zero article

The zero article is used after a preposition with unfocused singular countable generic nouns.

Food is classified as carbohydrate, fat, and protein.

Ethyl acetate smells like banana.

Certain traditional phrases take the zero article.

The center of the earth's core is, in fact, solid.

Break the glass in case of fire.

The programmers worked until at last they found the bug in the program.

The patient is improving day by day.

(Master, 2004, p.251)

Noun structure parallelism

The elements of English grammar often required in writing a description of a mechanism include the following:

- noun structure parallelism;
- magnitude statements;
- the prepositions at, on, and in;
- the active and passive voice;
- articles with classified and identified nouns;
- reduction of defining adjective clauses (subject-form).

Noun structure parallelism is important in creating the sentence in a description of a mechanism that tells the reader what the mechanism consists of (usually the plan-of-development sentence). Magnitude statements help the writer specify the size, shape, etc., of the parts of the mechanism. The prepositions *at*, *on*, and *in* show the relationships among the parts. The passive voice is often used in describing the location of parts and how the mechanism functions. Articles with classified and identified nouns keep track of the identity of the part that is being described. Reduced defining adjective clauses are necessary in describing the mechanism or its parts.

Parallelism refers to the fact that two or more noun structures, verb structures, or modifying phrases in the same sentence must have the same grammatical form, especially if they occur in a list (a series of structures) or in a plan-of-development sentence. Noun structure parallelism is concerned with the uniformity of noun structures in a sentence.

Types of Noun Structures

A noun structure consists of a noun phrase or clause. There are three types of noun structures in English:

1) noun phrases,

2) gerunds, and

3) noun clauses.

Type	Example
1. noun phrase nonmidified premodified postmodified pre- and postmodified	 *neuroscience* *modern neuroscience* *neuroscience in biophysics* *modern neuroscience in biophysics*
2. gerund (verb+ing) nonmodified premodified postmodified pre- and postmodified	 *mechanism understanding* *biophysics mechanism understanding* *mechanism understanding in science* *biophysics mechanism understanding in science*
3. ***noun clause*** (embedded WH-question word + phrase or infinitive, verb+ing) nonmodified premodified postmodified with a clause postmodified with verb infinitive	*what* (not possible) *what biophysics studies* *what to study*
4. ***noun clause*** (embedded yes/no-question: *that or if* + *phrase*) nonmodified premodified postmodified with a clause postmodified with verb infinitive	*that* (not possible) *that biophysics studies it* (not possible)

5. ***noun clause*** (embedded yes/no-question: *whether* + phrase or infinitive) nonmodified premodified postmodified with a clause postmodified with verb infinitive	(not possible) (not possible) *whether (or not) he studies it* *whether (or not) to study it*

Noun Clauses

Noun clauses include embedded questions and that-clauses.

Embedded questions

Embedded questions include embedded WH-questions and embedded yes/no questions.

Embedded WH-Questions

Embedded WH-questions are constructed by means of sentence combining. Like adjective clauses, they consist of a main clause and a subordinate clause. However, since an embedded WH-question is a type of noun clause, the subordinate clause can be either the subject or the object of the main clause. The subordinate clause is always a transformed WH-question which is embedded in the main clause.

Examples:

Subject *How the DNA functions*	Verb *is*	Compliment *still not known* (statement)
Subject *Biophysicists*	Verb *do not know*	Object *how the DNA functions* (statement)
Subject *Do biophysicists*	Verb *know*	Object *how the DNA functions?* (question)

Like adjective clauses, embedded WH-questions have both an object-form (O-form) and a subject-form (S-form). The subordinate clause in an O-form embedded sentence can be constructed with either a clause or an infinitive phrase.

Object-form embedded WH-questions

Object-form Wh-questions can be constructed

1) with a clause,

2) with an infinitive.

With a Clause

In an object-form embedded WH-Question, the question word is the object (or the object of a preposition) in the subordinate clause. (We know that the question word concerns the object rather than the subject because of the presence of the auxiliary verb *do* in the question. *Do* is only used with question words concerning the object, as shown in the following example:

The biophysicist does not know X. (main clause)

X = How does the DNA function (subordinate close)

(1) The biophysicist does not know how the DNA functions.

Sentence (1) requires four steps, as shown below:

X = *How does the DNA function?*

X_1 = *The DNA functions carrying out the genetic instructions.*

X_2 = *The biophysicist does not know* WHAT

X_3 = *how the DNA functions*

In X_1, we change the subordinate clause question into a statement by inventing an answer (*carrying out the genetic instructions*). In X_2, we replace the invented answer with what (because the invented answer is a fact). In X_3, we move the clause marker WHAT to the front of the clause (like the relative pronoun in an object-form relative clause). Once X is in the correct form (X_3), we substitute it in the main clause to arrive at Sentence (1):

The biophysicist does not know how the DNA functions

With an Infinitive

Object-form embedded WH-questions can also be constructed with an infinitive phrase. In sentence (1), the main subject *biophysicist* is different from the clause subject *DNA*.

(2) *The biophysicist does not know how the DNA functions.*

If the main subject and the clause subject are the same (or if a general subject such as people is meant), we can use

a) a subject plus a modal verb (***sentence 2a***) or

b) an infinitive verb in the embedded question (***sentence 2b***).

The subject plus modal verb usually indicates one time. An infinitive, since it has no tense, indicates general time, although it often implies a future event. Consider the following example:

The scientist knows X.

(2a) *The scientist knows what he should do. (one time)*

(2b) *The scientist knows what to do. (general time)*

Sentence (**2a**) indicates that the scientist knows what he should do in this particular case. Sentence (**2b**) indicates that the scientist knows what to do in general (i.e., he is well-trained and competent) and therefore what to do now and in the future,

Subject-form embedded WH-questions

In a subject-form embedded question, the question word is the subject of the subordinate clause. (We know that the question word concerns the subject rather than the object because there is no auxiliary form of do in the question).

As in the S-form relative clause, the question word *who* does not need to be moved because it is already at the beginning of the subordinate clause.

The scientists do not know X.

X= What changes the physical conditions.

The scientists do not know what changes the physical conditions.

Embedded Yes / No Questions

Embedded yes/no questions require the addition of *if* or *whether* (or not) to the statement form of a *yes/no question*. Embedded yes/no questions can function as both subjects and objects with *whether* (or not) but can only function as objects with *if*.

Whether or not the new object can be seen without a microscope is unclear.

It is not known whether or not *the new object* can be seen without a (Embedded yes/no question: *Can the new object be seen without a microscope)*

That-clauses

A *that-clause* is a sentence which has been made into a noun clause by adding the word *that*.

Example:

Scientists know X

X= Atoms have the core.

Scientists know that atoms have the core.

The word *that* may be deleted when the sentence is not too long.

Making Noun Structures Parallel

Noun structure parallelism is required if two or more noun structures occur as subjects, as objects or complements, or as objects of prepositions. These structures must all have the same form, e.g. all are gerunds, all are noun clauses, et. These noun structures are commonly connected by the words a) *and*, b) *both...and*, c) *or*, d) *either/or*, e) *neither/nor*, f) *not*, and g) *not only...but (also).*

Examples are shown below with the parallel noun structures in bold:

1) *He is a lecturer during the day and a scientist at night.*

2) *He admires both being a scientist and lecturing.*

3) *At first, he could not decide whether being a scientist or lecturing was the best profession.*

4) *His parents thought that he should be either a scientist or a lecturer, not both.*

5) *When he was studying at the university, he thought that he would be neither a scientist nor a lecturer.*

6) *Later, he thought that he should be a scientist, not a lecturer.*

7) *Now, he not only knows what a scientist does, but also knows what a lecturer does.*

Magnitude statements

Magnitude statements are often used in describing features. We describe the types of magnitude statements and how they may be modified.

Types of Magnitude Statements

The four most common types of magnitude statements are shown in the following examples:

Type 1	The wave is ten millimetres long.
Type 2	The wave is ten millimetres in length.
Type 3	The length of the wave is ten millimetres.
Type 4	The wave has a length of ten millimetres.

The type of magnitude statement selected depends on what is already known to the reader from prior information. In the examples above, Type 1 suggests that the wave is known but none of its dimensions. Type 2 suggests that the wave and its approximate size is known but not the particular dimension of length. Type 3 suggests that the wave and its length are known but not the precise measure of the length. Type 4 suggests that the wave is known but its particular characteristics are not.

While all the measurements nouns in Type 1 and many of those in Type 2 concern actual dimensions, many non-dimensional measurement nouns follow similar patterns.

Type 1

Type 1 magnitude statements may be described by the following pattern:

subject	be	measure	measurement adjective
The wave	*is*	*ten millimetres*	*long.*

Type 1 is the only type of magnitude statement that uses an adjective. The measurement adjectives used in Type 1 are the following:

long	high	tall
thick	wide	deep

They can be used with the words like mountains, clouds, pyramids, mountains, clouds, pyramids etc.

Type 2

Type 2 magnitude statements may be described by the following pattern:

subject	be	measure	in+0+measurement noun
The wave is	*is*	*ten millimetres*	*in length.*

Type 2 magnitude statements focus on the subject being described. The measurement nouns used in Type 2 are the noun forms of the adjectives in Type 1 (except tall) and other nouns

length	breadth	diameter
width	arc	intensity (of sound)
thickness	altitude	mass
depth	area	weight
height	circumference	volume

Type 3

Type 3 magnitude statements may be described by the following pattern:

The + measurement noun + of	subject	be	measure
The length of	*the wave*	*is*	*ten millimetres.*

Type 3 magnitude statements shift the focus from the subject being described to the measurement noun, The nouns used in this structure are all those used in *Type 2*. Additional examples are listed below. Many of these measurement nouns can be modified to produce new concepts, e.g., *gear ratio, moisture content, initial cost, escape velocity, atomic number*.

accuracy	gravity	range
amount	growth	rate
boiling point	heat of vaporization	ratio
capacity	index of refraction	resistance
coefficient of expansion	magnitude	span
content	melting point	specific gravity
cost	number	speed
density	population	temperature
elevation	pressure	thermal conductivity
force	proportion	velocity
freezing point	quantity	viscosity voltage

A few measurement nouns require the preposition between instead of *of:*

angle between	difference between	distance between.

TYPE 4

Type 4 magnitude statements may be described by the following pattern:

subject	have	a+ measurement NOUN+of	measure
The wave	*has*	*a length of*	*ten millimetres*

The nouns used in this structure are the same as those used in *Type 2* and *Type 3* (except for those with between, which can only be Type 3)

Modifying the basic magnitude statement

All parts of the basic magnitude statement may be modified:

a) the subject,

b) the verb,

c) the measure,

d) the measurement noun.

The only exception is the measurement adjective in *Type 1*, which cannot be modified in any way.

Modifying the subject

The subject in all four types of magnitude statement may be modified by premodification and/or postmodification.

premodification

The sound ***wave*** *at standard temperature* *is seventeen mm long*

postmodification

Modifying the verb

The verb in all four types of magnitude statements may be replaced with a modal auxiliary verb, particularly in specifications:

Type 1	*The sound wave*	*shall be* *should be*	*seventeen mm long*
Type 2	*The sound wave*	*must be*	*seventeen mm in length*
Type 3	*The length of the sound wave*	*will be* *is to be*	*seventeen mm*
Type 4	*The sound wave*	*shall have* *should have* *must have*	*a length of seventeen mm*

		will have *is to have*	

The modal auxiliary *shall* is used in formal specifications,

Although *be* is the most common verb in *Type 3* statements, it can be replaced with other verbs, such as *to equal, to be equal to,* and *to average* (if more than one object is implied).

The length of the sound wave equals seventeen millimeters.
The length of the sound wave is equal to seventeen millimeters.
The length of the sound waves averages seventeen millimeters.

Modifying the measure

The actual measure given in *Type 1*, *Type 2*, and *Type 3* magnitude statements may be qualified as to its exactness. Some common qualifying words and phrases are:

exactly, precisely	*The wave is <u>exactly</u> 2.131 meter long.*
just under, just over	*The wave is <u>just under</u> 2 meter long*
about, approximately, around	*The wave is <u>about</u> two meters in length*
under, over	*The wave is <u>over</u> two meter in length*
on the order of	*The length of the wave is <u>on the order</u> of two meters*
roughly	*The length of the wave is <u>roughly</u> two meters.*

Modifying the measurement noun

The measurement noun is usually only modified in *Type 3* and *Type 4* statements. (Of course, if you qualify the measure in *Type 3*, it would be redundant to qualify the measurement noun, too.)

precise, exact	The wave has a precise length of 2.131 meters.
approximate	The wave has an approximate length of 2.1 meters.
rough	The wave has a rough length of two meters.

THE PREPOSITIONS *AT*, *ON*, AND *IN*

The three most commonly used prepositions are *at*, *on*, and *in*.

The Preposition At

The preposition ***at*** commonly refers to a position or a location that implies a function. It represents one dimension (i.e., a point or goal).

Position of time, place, or measure

Examples:

1. The satellite was launched at 5:39 A.M.
2. The core is at the center of the atom.
3. Aluminum melts at a temperature of 660°C.

(at + a measurement noun is a common structure),

Other Uses:

at the age of	at a level	at the surface
at the beginning	at a node	at the terminal
at the bottom	at a point	at the top
at the end	at a stage	

Location that implies function

Examples:

1. The scientist is at the laboratory today (The scientist may be inside or outside the actual laboratory. This sentence indicates that the scientist is doing the things one normally does in a laboratory).

2. The employee is at the office (i.e. the employee is doing what one normally does at a office, such as writing emails, phoning the clients, or taking part in the meetings).

Other Uses:

at the airport	at the garage	at school
at the bank	at home	at the store
at court	at the hospital	at work

The Preposition On

The preposition *on* commonly refers to a line or a surface. It represents one dimension (a line) or two dimensions (i.e., a surface or a plane).

Line

Examples:

Constructing heavy objects <u>on a bridge</u> is not recommended.

Boiling point is 212°C <u>on the Fahrenheit scale</u>.

Other Uses:

on the average	on a line
on the edge	on a path
on the gauge	on the verge (of)

Surface

Examples:

Check the measurements <u>on the altimeter</u>.

Oxides <u>on the surface</u> prevent the iron from corrosion.

Other Uses:

on the affected area	on a plane
on the face (of)	on a side

The Preposition In

The preposition *in* commonly refers to containment or mode. It represents three dimensions (i.e., a cube or containment in three dimensional space).

Containment

Examples:

The samples of bacteria are in the test tubes.

The computer is failed because of bugs in the program.

Other Uses:

in the body	in a manometer	in a position
in this case	in the ocean	in a range
in the circuit	in a plane	in a situation
in a liquid	in this problem	in a tank

Mode: measure, direction, action

Examples:

1. The wave is two meters in length.
2. The water flowed in an eastward direction.

At, On, and In in Relation to Time

In relation to time, the following diagram may help you to remember the uses of *at*, *on*, and *in*:

AT	Time: The satellite was launched at 3:40.
ON	Day: The meeting is on Monday. Date: The first experiment took place on June 14. 1995.
IN	Month: Sunspots are most active in March. Season: It usually rains here in spring. Year: The Large Hadron Collider was finished in 2008. Decade: The graphical user interface was developed in the 70s. Century: Sir Isaac Newton was born in the 17th century.

Noun Compounds

Part 1

Compound nouns are formed by combining two or more words to create a single noun that represents a specific concept or object. In physics, there are many compound nouns used to describe various phenomena, tools, and concepts as well as the complex and fascinating aspects of the natural world.

Compound nouns can be made of different parts of speech. Here are some examples:

noun	+	*noun*	*wavefunction, time dilation, background, footprint*
noun	+	*verb*	*starfall, sunrise, manmade*
noun	+	*adjective*	*photoelectric, astrophysical*
verb	+	*noun*	*washing machine, driving licence*
verb	+	*preposition*	*standby, built-in*
verb	+	*adverb*	*drawback, takeover*
preposition	+	*noun*	*exoplanet, outlook, output, input, inside*
adjective	+	*noun*	*superconductivity, software,*
adverb	+	*noun*	*online, oversize, overdue*

Part 2

Compound nouns can be formed in three ways:

- Two words are written together (closed compound nouns):
  underground, keyboard, holographic, wavelength
- There is a hyphen between words (hyphenated compound nouns):
  in-law, X-ray
- The words are not connected in any way (open compound nouns):
  black hole, quantum mechanics, dark matter

Part 3

The difference between compound noun and words that are paired with one another lies in the meaning and photoinitiation. Certain compound nouns are homophones with two-word phrases. For example, green house vs. Greenhouse. Compare:

Greenhouse effect is harmful for the ecology.

I live in a green house.

Typically, a compound word places stress on the first word. When two words simply exist beside each other in a sentence, they generally receive the same amount of stressing.

*Gr**ee**nhouse – gr**ee**n h**o**use*

*Sm**a**rtphone – sm**a**rt ph**o**ne*

Part 4

Compound nouns can be pluralized. Generally, you pluralize a compound noun by pluralizing the semantic head, the part of the word that conveys its primary meaning. For example:

*Doctor of philosophy – doctor**s** of philosophy*

*Black hole – black hole**s***

Note that is the word has irregular noun as a semantic head, it is not pluralized in traditional way, because it doesn't stand alone. Thus, we will get

Footprints (but not feetprints)

Other and its relatives

Part 1

The word "other" and related words like "another," "others," and "another's" are commonly used in English to indicate a distinction between different things or to refer to additional or different options. Compare the use of "other" and "another":

Other	Another
Can be used with plural, and uncountable nouns	**Can be used only with singular countable nouns (since another = an + other)**
Compared to other experiments, this one demonstrated excellent results.	*We need to make another experiment to prove out hypothesis.*
Used to compare, contrast, or distinguish between different things or groups	**Refers to an additional or different thing of the same kind.**
In this lab we can only conduct chemical experiments, the other ones should be performed in room 5.	*This tool is broken, could you give me another one?*
Can be used to refer to a second of two things	**It implies that the thing mentioned is not the same as the one previously mentioned or considered**
On one hand we see progress, but on the other there is a sharp decrease in production.	*Why don't you use another method of solving this task?*

Part 2.

The use of "Others" and "Another's"

"Others" is a plural form of "other" and is used to refer to additional things or people that are not specifically mentioned.

Some institutions adopted the new evaluation system, while the others preferred the old one.

"Another's" is the possessive form of "another" and is used to indicate possession by someone else.

We couldn't come up with our own solution, thus used another's idea to test these programmes.

Part 3.

Comparative and superlative forms:

"Other" has comparative form – "different" or "more different", depending on the context, and superlative – "the other(s)"

This solution is different from the other one.

Of all the choices, I like this one the best; the others aren't as appealing.

Part 4.

Collocations with "other" and "another"

Each other (used to talk about people in a group that interact):

The students helped each other during the exam session.

Researchers inform each other about the results of their studies by publishing their papers.

One another (similar to "each other", emphasising mutual interaction):

In a healthy team relationship, team members should respect one another.

The other way around (similar the "vice versa" referring to the opposite situation):

I thought we would study some practical issues, but it's actually the other way around.

Some… others (indicating a distinction between different parts of a group):

Some students have chosen to study mechanical engineering, while others preferred computer one.

The other day (A recent or unspecified day in the past)

We participated in the exhibition the other day.

Other than (except for; excluding):

We don't have any lessons today other that mathematics.

One after the other (in a sequence):

He had to complete the tasks one after the other.

Collocations with "another"

Another time (later, at a different time):

We were suggested to organize a meeting another time.

Another reason (an additional cause or explanation):

Another reason for participating in this project is creating patented innovation.

Another level (To a higher degree of intensity, complexity, or quality)

The experiment results bring us to another level of the current study.

Another option (an alternative choice or possibility):

First, we can try to contact other internal institutions, another option would be searching for international scientific communities.

Coordination and Subordination

Part 1.

Coordination and subordination are two ways of combining sentences. Coordination means combining two sentences or ideas that are of equal value. Subordination means combining two sentences or ideas in a way that makes one more important than the other. Compare:

Coordination: The system was updated, and the new software was installed.

Subordination: Since the new software was installed, we had to update the system.

Part 2.

Coordinators. Here are some examples of coordinators.

- ***F****or (effect/cause): Many students preferred studying online,* ***for*** *they had the possibility to combine work and studying.*
- ***A****nd (addition): While doing the first two years in our university students have compulsory subjects,* ***and*** *in Oxford most subjects are optional.*
- ***N****or (addition of negatives): Harry doesn't want to enter any university,* ***nor*** *does he want to find a job.*
- ***B****ut (contrast): Tim likes listening to podcasts,* **but** *he prefers to watch videos.*

- ***O**r (alternative): Jose thinks he wants to study math,* **or** *he might be interested in engineering.*
- ***Y**et (contrast): Justin really enjoys physics,* ***yet*** *he hates doing any kind of calculations.*
- **S**o (cause/effect): Maria loves optics, **so** she has bought an illustrated book about the advances in sphere of optics and holography.

Part 3.

Transition words

You can also use transition words (also known as conjunctive adverbs) to coordinate sentences, although they require different punctuation. If you are joining two sentences with a conjunctive adverb, you need to have a semi-colon before the word and a comma after it.

- *however (contrast): Some analytics predict that due to AI some professions, like software developers may disappear;* ***however****, I still attend a special course of software engineering.*
- *therefore (cause/effect): Neural networks are becoming more developed;* ***therefore****, they will be applied in many spheres of our life in future.*
- *for example (general to specific): There are many types of engineering that are studied in our university;* ***for example****, I teach electronic and computer engineering.*
- *in fact (emphasis): There are two renovated laboratories in out department; in fact, one of them has just been finished a few days ago.*

Part 4.

Subordinators or Subordinating Conjunctions

To subordinate one sentence to another, use a connecting word called a "subordinator." The following words are examples of subordinators.

- **although, even though, though, whereas, while (contrast):**

Michelle wants to work as a university professor, even though she finds writing scientific papers boring.

- **Because, since (cause/effect):**

Marty studies grammar hard because he is taking IELTS this month.

- **after, as soon as, before, whenever, when, until (time):**

When Kate submits her reports, she attaches all the necessary documents.

- **if, unless (condition):**

If we complete this topic this week, we will be able to start our practical part.

Most, the most, mostly

Part 1.

Most.

We use the quantifier *most* to talk about quantities, amounts and degree. We can use it with a noun (as a determiner) or without a noun (as a pronoun). We can also use it with adjectives and adverbs to form the superlative.

***Most* with a noun**

We use *most* with nouns to mean 'the majority of':

Most students of our department prefer online format of education.

Most tap water is not drinkable in our district.

Warning:

We don't use *the most* with this meaning:

*The sun shines over 800 hours during June, July and August and on **most** days temperatures rise above 25 degrees.*

Not: … ~~and on the most days~~ …

When we are talking about the majority of something in general, we use *most* + noun. When we are talking about the majority of a specific set of something, we use *most of the* + noun.

Compare:

***Most** companies use internal networks.*	*Companies in general*
*This year we have updated **most of the** equipment at our office.*	*A specific piece of equipment (located at our office)*

Part 2.

When we use *most* before articles (*a/an, the*), demonstratives (*this, that*), possessives (*my, your*) or pronouns (*him, them*), we need *of*:

***Most of** the information was useful. Some of it wasn't relevant.*

Not: ~~Most the information~~ …

*They completed **most of** their tasks quite quickly.*

Warning:

When there is no article, demonstrative or possessive pronoun, we don't usually use *of*:

*There hasn't been much rain. **Most rivers** are below their normal levels.*

Not: ~~Most of rivers are below their normal levels~~.

We use *most of* before geographical names:

Most of England and Wales should be dry throughout the day.

Most without a noun

We can leave out the noun with *most* when the noun is obvious:

*Some teachers offered to write a progress test but **most** preferred to have only a final one. (most teachers)*

Part 3.

The most

The most is the superlative form of *many, much*. We use *the most* with different classes of words.

The most **with adjectives and adverbs**

We use *the most* to make the superlative forms of longer adjectives and the majority of adverbs:

*They're using **the most** advanced technology in the world.* (+ adjective)

*Scafell Pike is **the most** easily identifiable peak in the Lake District.* (+ adverb)

The most **with a noun**

We use *the most* with a noun to mean 'more/less than all of the others':

*Ian submitted **the most** papers in our group.*

We can leave out the noun when it is obvious:

*He didn't tell the best jokes but he told **the most**. (the most jokes)*

The most **with a verb**

We use *the most* with a verb as an adverb:

*They all were trying hard to complete the task, but Claire tried **the most**.*

Part 4.

Mostly

Mostly is an adverb that means 'mainly':

*I am **mostly** interested in the history of mechanics. (I am interested in other things about mechanics but my main interest is its history.)*

We don't use *mostly* instead of *most* or *the most*.

Compare

*What I liked **most** were interesting lectures.* Not: ~~*What I liked mostly were interesting lectures*~~.	*I liked the interesting lectures more than anything else.*
*Which beaches did you like **most?***	*Which lectures were the ones that you liked more than any others?*
We mostly attended lectures.	*We were at lectures for the majority of the time.*

Infinitive and Gerund structures

Verb patterns

VERB + -ing	VERB + to + infinitive	VERB + object + to +inf.
admit	*afford*	*advise*
adore	*agree*	*allow*
allow	*allow (passive)*	*ask*
avoid	*appear*	*beg*
can´t stand	*arrange*	*encourage*
carry on	*ask*	*expect*
consider	*attempt*	*force*
deny	*choose*	*invite*
delay	*dare*	*order*
(don´t) mind	*decide*	*permit*
enjoy	*expect*	*persuade*
fancy	*fail*	*recommend*
finish	*forget*	*remind*
give up	*help*	*teach*
imagine	*hope*	*tell*
involve	*learn*	*want*
keep	*manage*	*warn*
keep on	*offer*	*would like*
postpone	*plan*	
practise	*pretend*	
put off	*promise*	
recommend	*refuse*	
risk	*seem*	
suggest	*tend*	
	threaten	

	want *would like to*	

Gerund and infinitive verb patterns refer to the use of either the gerund (the -ing form of a verb) or the infinitive (the base form of a verb with “to”) after certain verbs. The choice between gerunds and infinitives depends on the verb that precedes them. Here are some common verb patterns with gerunds and infinitives:

verb + *-ing*

Many verbs can be followed by a verb in the *-ing* form.

Some of these verbs are related in meaning: *like, dislike, adore, love, detest, can’t bear/stand.* Some can also be followed by the infinitive, but the meaning may change.

We regret to inform you ... *(We are sorry before we speak.)*

He regrets telling her... (He is sorry after he speaks.)

Prepositions are followed by an –ing form.

Are you still interested in joining Tesla project?

-*Ing* forms when they function as nouns (gerunds) are often the subject of a sentence.

Joining Tesla project is beneficial in terms of…

infinitive with to

Use an infinitive with to:

- after certain verbs including appear, decide, fail, need, offer, refuse, want, wish.

Verbs with a future meaning (hope, expect, promise, etc.) are often followed by the infinitive.

They hoped to negotiate a better deal.

- after certain verb + object combinations, e.g. ***advise, allow, ask, cause, encourage, forbid.***

The police asked everyone to remain calm.

- with some nouns, often as part of semi-fixed phrases: It’s time to ..., etc.).
- after most adjectives: …*was eager to investigate the case…*

passive infinitive or -ing form

Use the passive -ing form (being done) to describe actions which are done to the subject: *…hate being told what to do.*

Use the passive infinitive (to be done) after some verbs (especially reporting verbs).

Iron was considered to be the best conductor for the...

perfect infinitive or -ing form

Use the perfect -ing form (having done) or the perfect infinitive (to have done) to emphasise when one action happened before another:

The scientist mentioned having seen him leave.

They seem to have solved the problem.

After verbs of preference (would like/love/hate/ prefer/rather) we can use the perfect infinitive to talk about an action in the past.

We would hate to have lost the match.

negative infinitive or -ing form

Not + infinitive and not + -ing are also important.

It's quite common not to understand at first.

Not understanding is quite common.

Infinitives can be the subject of a sentence.

To learn is important.

Not to thank her would be impolite.

Note!

There are some ***exceptions*** in use. Some verbs have a different meaning depending on whether they are followed by an -ing form or to + infinitive.

a) ***stop***

Stop + -ing means the action is not happening any more.

Without delay, they immediately stopped doing any further debugging and started analyzing the code for conflicts.

Stop + to + infinitive means that someone or something stops an activity so that they can do something else.

Concerned about the equipment's integrity, they immediately stopped to inspect the source of the vibration.

b) try

Try + -ing means that you are trying something as an experiment, especially as a possible solution to a problem, to see if it works or not.

They decided to try optimizing the code by implementing a more efficient sorting algorithm.

Try + to + infinitive means that something is difficult but you are making an effort to do it.

Despite several failed attempts to identify the root cause, they decided to try to refactor the problematic function for better clarity and debugging.

c) remember/forget

Remember + -ing and forget + -ing refer to having (or not having) a memory of something in the past.

To avoid missing any critical scenarios, they made a checklist to remember documenting each step of the testing process.

In their haste, they accidentally forgot including an important security patch in the release notes.

Remember + to + infinitive and forget + to + infinitive refer to recalling (or not recalling) that there is something we need to do before we do it.

The network administrator knew the importance of security, so they made sure to remember to change the default login credentials for all the connected devices.

The project manager was overseeing the installation process and realized they had forgotten to allocate sufficient resources for configuring the firewall.

Participial clauses

Usage

Participle clauses are common in written language. We can use them to shorten active and passive sentences.

Active Sentences

Use the present participle (ing-form) to show that two actions are taking place at the same time.

Example:

The engineers, designing the electric vehicle's battery system, prioritize energy efficiency and longevity.

Instead of the long form: The engineers, who were designing the electric vehicle's battery system, prioritize energy efficiency and longevity.

Use **the perfect participle** *to indicate that the action in the participle clause took place before the action in the main clause.*

Example:

Having been meticulously assembled by our skilled technicians, the product is now ready for quality testing.

Instead of the long form: *The product which has been meticulously assembled by our skilled technicians, is now ready for quality testing.*

Passive Sentences

We use the past participle to shorten a passive clause.

Example:

The developers, programmed with the latest coding standards, are confident in the software's stability.

Forming Participle Clause in English Grammar

There is no subject in a participle clause. The subject of the main clause is also the subject of the participle clause.

Example:

The software development team, ***led*** *by John, completed the project ahead of schedule.*

The main verb is changed into a participle. We have to pay attention to whether the action in the participle clause takes place at the same time as the action in the main clause or before it, and whether we are using the active or the passive voice.

Example:

Having conducted extensive research on materials and methods, the engineers confidently implemented their findings in the new manufacturing process. (simultaneous action, active - present participle)

Prepositions of time

Prepositions of time – here's a list of the time words that need 'on', 'in', 'at' and some that don't need any preposition.

at (for specific times)	**on (for specific days)**	**in (for time periods)**	**no preposition**
times: at 8pm, at midnight, at 6:30 holiday periods: at Christmas, at Easter at night at the weekend at lunchtime, at dinnertime, at breakfast time	days: on Monday, on my birthday, on Christmas Day days + morning / afternoon / evening / night: on Tuesday morning dates: on the 20th of June	years: in 1992, in 2006 months: in December, in June decades: in the sixties, in the 1790s centuries: in the 19th century	next week, year, month etc last night, year etc this morning, month etc every day, night, year etc today, tomorrow, yesterday

		seasons: in winter, in summer in the morning, in the afternoon, in the evening	

Verb Tenses

Past Simple:

Verb Form: Regular verbs use **the base form + “-ed,”** and ***irregular verbs*** have their own past forms.

We use the past simple tense to describe completed actions in the past, often with specific time references:

a) For an action which happened at a definite time in the past. The time is stated, already known or implied.

Yesterday they conducted an experiment.

The experiment ***concluded*** *last week.* (Specific time reference)

b) For actions which happened immediately one after the other in the past.

First they conducted an experiment, then they proceeded to a scientific research.

c) For past habits or states which are now finished. In such cases we can also use the expression ***used to.***

They conducted/used to conduct an experiment every day in 1998.

The past simple is used with the following time expressions: *last week, yesterday, the day before, in 1998, then, when, How long ago…, three days ago, etc.*

Past Perfect:

Use the past perfect tense to indicate an action that happened before another action or before a stated time in the past.

Verb Form: **Had + past participle.**

Example:

By the time we arrived, the team ***had already assembled*** *the equipment.*

Before we started the maintenance, the technicians ***had already identified*** *the faulty component.*

The past perfect is used with the following time expressions: *before, after, already, just, for, since, till/until, by, be the time, never.*

Past Continuous:

Verb Form: Was/were + present participle (-ing form).

We use the past continuous:

a) For an action which was in progress at a stated time in the past. We do not mention when the action started or finished.

Th*e engineers were conducting an experiment all the previous week.*

b) For an action which was in progress when another action interrupted it. We use the past continuous for the action in progress (longer action) and the the past simple for the action which interrupted it (shorter action).

While the engineers ***were conducting*** *tests, the system suddenly crashed.*

While the team ***was troubleshooting****, they discovered a voltage drop in the circuit.*

c) For two or more simultaneous actions.

While the engineers were conducting tests, the team was troubleshooting.

Present Perfect:

Verb Form: Have/has + past participle.

We use the present perfect:

a) for an action, which started in the past and continues up to the present, especially with state verb such as be, have, like, know, etc. In this case, we often use *for* and *since*.

The robot ***has had*** *this high performance plate since they bought a license.*

b) for an action which has recently finished and whose result is visible in the present.

I ***have just finished*** *reading the user manual, so I can now operate the machinery effectively.*

c) For an action which happened at an unstated time in the past. The exact time is not mentioned because it is either unknown or unimportant. The emphasis is placed on the action.

The engineer ***has accumulated*** *significant experience in designing high-performance algorithms.*

The present perfect is used with the following time expressions: for, since, already, yet, always, just, ever, never, so far, this week/month, etc., how long, lately, recently, still (in negations), etc.

Non-defining Adjective Clause

A non-defining adjective clause, also known as a non-restrictive or non-essential adjective clause, is a type of clause used in English grammar to provide additional information about a noun in a sentence. However, it does not restrict or define the noun; instead, it offers extra, non-essential details. Non-defining adjective clauses are set off by commas and can usually be removed from the sentence without changing its core meaning.

The professor, who has published numerous papers on quantum physics, is giving a lecture.

In this sentence, "who has published numerous papers on quantum physics" is a non-defining adjective clause. It provides additional information about "the professor," but it doesn't restrict the meaning of "the professor." You could remove the clause, and the sentence would still make sense: "The professor is giving a lecture."

Key points about non-defining adjective clauses:

Set off by Commas: Non-defining clauses are usually enclosed in commas, both before and after the clause.

Provide Extra Information: They add descriptive details or explanations about a noun but are not crucial for understanding the main message of the sentence.

Can Be Removed: You can often remove a non-defining clause from a sentence without changing the essential meaning or structure.

Use "who," "which," or "whose": These relative pronouns (and occasionally "whom") are commonly used to introduce non-defining adjective clauses.

Useful for Adding Detail: Non-defining clauses are helpful when you want to provide additional information or context about a noun without making it an integral part of the sentence.

In contrast, defining adjective clauses (restrictive clauses) provide essential information about a noun and are not set off by commas. Removing a defining clause from a sentence would change its meaning or render it grammatically incorrect.

Causation

The relationship between a cause and an effect can be expressed in several ways.

Part 1

Verbs and verb phrases:

*Modern civil engineering techniques **have Ied to** the use of better construction methods.*

__________***A***___________***B***___________***C***_____________

Where A=the cause; B=the verb linking the cause to the effect; C=the effect.

Here are other verbs and verb phrases with a similar meaning:

account for cause
result in
bring about
give rise to
be responsible for

Alternatively, we can also reverse the elements in the sentence:

*The use of better construction methods **resuIts from** modern civil engineering techniques.*

__________***C***___________***B***___________***A***_____________

Where A=the effect; B=the verb linking the effectto the cause; C=the cause.

Here are other verbs and verb phrases with a similar meaning:

arise from
be attributable to
stem from

Part 2

Clauses of cause:

*We have moved over to water turbines **because** they offer significant cost savings.*

In this sentence a subordinating conjunction links the effect and the cause.

Here are the other main subordinating conjunctions:

as
since

Part 3

Phrases of cause:

Many accidents during experiments happen ***due to*** *poor security procedures.*

Here an adverb phrase introduces the cause.

Other expressions with a similar meaning are:

as a consequence of
because of
on account of
owing to

Study the following text that shows the above language in use:

Combustion is a reaction in which the oxidization of an element or compound ***Ieads to*** *the release of energy. If the combustion* ***resuIts in*** *a flame, it is called burning.* ***Since*** *combustion can be dangerous, it is important to take precautions against injury. However, not all combustions* ***resuIt in*** *flames. For instance, the combustion of carbon in oxygen* ***causes*** *an intense red-white light but no flame. Petroleum, on the contrary, requires special handling* ***on account of*** *its volatility.*

Obligation and requirements

Part 1

Form

We can view the notion of obligation under the following headings:

1) **obligation to do something;**
2) **obligation not to do something, i.e. prohibition;**
3) **no obligation.**

We can also view the notion from the point of view of the person/situation causing the obligation (the obliger), and the person receiving the obligation (the obliged). Here is the range of verbs for the obliger:

1. **Oblige someone to do something:**

compel
demand
force
make
oblige
require

2. **Oblige someone not to do something:**

ban
forbid
prohibit

3. **Not oblige someone to do something:**

not compel
not force
not make
not require

Here is the range of verbs for the obliged:

1. **Obliged to do something:**

be forced to
be required to
be supposed to
have to
must

need to

2. **Obliged not to do something:**

be prohibited from
cannot
may not
must not
not allowed to
not be permitted to

3. **Not oblige someone to do something:**

do not need to
need not
not have to

Part 2

Uses

1. To oblige someone to do something:

*We **require** the general approach to supervise and co-ordinate the experiment.*

2. To oblige someone not to do something:

*The use of this device is **banned**.*

3. Not to oblige someone to do something:

*The construction engineers don't normally **force** painters, plasterers and plumbers to use specific products.*

4. To be obliged to do something:

*The contractor **must** apply flame-retardant chemicals to slow down the spread of fire.*

5. To be obliged not to do something:

*A nonload-bearing wall **must not** support any other load except its own weight.*

6. Not obliged:

In this type of soil we ***needn't*** *dig the foundations deeper than 10 metres.*

Ability and Inability

Part 1

Form

We can view the concepts of ability and inability in terms of:

1) **making someone able or something possible:**

The database ***allows*** *you to search for client names and addresses.*

2) **being able:**

This new monitor ***can*** *display more than two million colours.*

3) **making someone unable or something impossible:**

The climate ***stops*** *people from wearing this type of heavy jacket – it's just too hot.*

4) **being unable:**

You ***can't*** *press this material with a hot iron as it is too sensitive.*

Look at the use of language for the concepts 1-4 above:

1	2	3	4
make able	*be able*	*make unable*	*be unable*
enable	*can*	*prohibit*	*cannot*
allow	*able to*	*prevent*	*not able / unable to*
permit	*capable of*	*stop*	*incapable of*

Part 2

Uses

Now look at the following short text which demonstrates the use of these verbs:

Now you ***can*** *create your own website. So simple, anyone is* ***capable of*** *producing a quality site in minutes. You'll be* ***able*** *to add graphics and photos. This new software* ***allows*** *you to work with all types of graphic files. The text editing function*

enables *you to work directly from your word processor. Remember: only one registered user is* ***permitted*** *to use this software.*

Part 3

Note

1) **We use the *infinitive* with *to* after *able / unable*, e.g.:**

You'll be ***abIe to*** *add graphics and photos.*

Synthec fibre is ***unabIe to*** *replace natural fibre.*

2) **After *capable / incapable* we use of + verb…ing, e.g.:**

Anyone is ***capabIe of producing*** *a quality site in minutes*.

They are ***incapabIe of producing*** *these elements in a wide range of colours.*

3) **After *prohibit*, *prevent* and *stop*, we use the following constructions:**

Local regulations ***prevent / stop*** *us from importing tee shirts from certain countries.* (from + verb...ing)

Local regulations ***prevent / prohibit*** *the importation of tee shirts from certain countries*. (noun)

Scale of Lilkelihood

Part 1

Form and uses

If we consider that the scale of likelihood goes from 100% certainty to 0% certainty, we can identify the following segments. (The numbers below are only a general indication. Not exact values):

certainty	*(100%)*
probability	*(75%)*
possibility	*(50%)*

improbability	*(25%)*
impossibility	*(0%)*

Now let's look at the language for each of these categories.

certainty	*I am (absolutely)* ***sure / certain / positive*** *that power requirements will increase.* *Power requirements will* ***definitely / certainly*** *increase.* *Power requirements are* ***certain / sure / bound*** *to increase.*
probability	*It is (very)* ***likely / probable*** *that the pumps will use more electricity.* *The pumps are (quite)* ***likely*** *to use more electricity.* *They* ***could*** *use more electricity.*
possibility	*We* ***may / might*** *need more pumps on site.*
improbability	*It is (very/highly)* ***unlikely / improbable*** *that the pumps will use more electricity.* *The pumps* ***probably*** *won't use more electricity.* *The pumps are (quite)* ***unlikely*** *to use more electricity.* *The pumps* ***shouldn't*** *use more electricity.*
impossibility	*I am* ***sure / certain / positive*** *that power requirements won't increase.* *Power requirements* ***definitely / certainly*** *won't increase.* *Power requirements* ***can't (possibly)*** *increase.*

Part 2

Use

1. **Definitely and certainly**

Notice the position of the adverbs in certainty and impossibility:

We wiII ***definitely / certainly*** *replace the fuses. (after wiII)*

*The fuses **definitely / certainly** won't fail. (before won't)*

2. **Likely and unIikely**

These adjectives can take two constructions:

*lt is **likely / unlikely** that the pumps will use more electricity. (adjective + that + clause)*

*The pumps are **likely / unlikely** to use more elecricity. (adjective + to + infinitive)*

3. **May and might**

Some speakers feel there is a slight difference in the strength of these two words:

*We **may** need more pumps on site. (50% likelihood)*

*We **might** need more pumps on site. (45% likelihood)*

Subordinate Clauses of Result and Purpose

Part 1

Form

Clauses of result and purpose are subordinate clauses. There are three possible constructions:

1. **(in order/so as) to + infinitive:**

*Benton have defined quality control standards **(in order) to meet** minimum product specifications.*

2. **A subordinatíng conjunctíon followed by a verb:**

*We sample and monitor all processes **so that** customer needs **are exceeded**. (purpose)*

*Last year Markham introduced new quality standards **so (that)** they **detected** defectíve products before completion. (result)*

3. ***For + noun* followed by an *infinitive + to***

***For** zero defects **to be achieved**, we will have to introduce tighter prevention controls. (= **so that** zero defects **can be achieved**, we ...)*

The main subordinating conjunctíons are:

in order that
so that

Before the *infinitive + to* you can put:

for
in order (to)
so as (to)

Note the negative forms:

So as not to *pay for unnecessary reworking, we sample all raw materials.*

In order not to *lose customers, we have a policy of continuous process improvement.*

Part 2

Uses

Clauses of purpose answer the question *why* or *what ... for*. They present the purpose of the information in the main clause.

Clauses of result also answer the question *why* or *what ... for*. In contrast to clauses of purpose, they typically look to the past to see what result an action achieved.

Electricity is usually transmitted at the highest voltages possible to minimize energy lasses. ***(purpose)***

We tied together the electric utilities into large systems so that power was exchanged. ***(result)***

Now look at the differences between the constructions in clauses of purpose and result:

1. **We use *to, in order to* and *so as to + infinitive* when the subject of both clauses is the same.**

Energy is generated from different fuels ***in order to*** *avoid reliance on one source.*

2. **We use *so that* or *in order that* where the subject of the dauses is different.**

Electricity producers are able to exchange power ***so that*** *one utility can assist another.*

3. **We use *so that* + clause for clauses of result.**

*These electric utilities were then combined into larger systems **so that** power was exchanged.*

Part 3

Notes

The following sentences are wrong:

We use coal ~~for make~~ energy. (to make)

We changed to gas ~~for to make~~ energy. (in order to make)

We started producing hydroelectric power ~~for making~~ cleaner energy. (to make)

APPENDIX 4. LISTENING SCRIPTS

UNIT 1. PARTICLE PHYSICS

GROUNDWATER PUMPING BY HUMANS

Perhaps it's only geophysicists who are aware of the importance of underground reservoirs on maintaining Earth's balance. Geophysicist Ki-Weon Seo from Seoul National University has discovered that humans have extracted so much groundwater from under our feet that they have changed the tilt of Earth's axis. This shift has been significant enough to physically relocate the geographic North Pole. The mass of polar ice is drifting by 4.36 centimetres a year. Professor Seo calculated that we extracted more than two trillion tons of groundwater between 1993 and 2010, causing Earth to wobble. Seo added that the pumping of groundwater has caused sea levels to rise by 6.24 millimetres. Professor Seo explained how groundwater affects Earth's gravity. He said: "Every mass moving around on the surface of the Earth can change the rotation axis." Scientists have only recently discovered how groundwater can change Earth's axis. They previously believed water-driven shifts were caused by melting glaciers and ice caps. Seo and his colleagues were puzzled at how this could cause such a tilt. They concluded that the depletion of underground water was also a factor. Much of the extraction of groundwater is due to irrigation, especially in north-western India and western North America. Another researcher said: "The very way the planet wobbles is impacted by our activities."

Taken from https://breakingnewsenglish.com/2306/230619-earths-axis.html

A ZEPTOSECOND

In today's world, many things are getting shorter and shorter. Scientists have just measured something incredibly short. They recorded the shortest unit of time ever measured. It is called a zeptosecond. This is a tiny, tiny, tiny fraction of one second. It is a trillionth of a billionth of a second. This is a decimal point followed by 20 zeros and then a 1. The scientists study atomic physics at the Goethe University in Germany. They used special high-tech equipment to measure how long it takes a photon to cross a hydrogen molecule. The scientists said it took 247 zeptoseconds for this to happen. This is too small for the human eye to see, and the time it takes is too fast for humans to sense. In 1999, Ahmed Zewail, an Egyptian chemist won the Nobel Prize in Chemistry for measuring the speed at which molecules change their shape. He found that one femtosecond equals 0.000000000000001 seconds. This is a decimal point followed by 14 zeros and then a 1, or a millionth of a billionth of one second. The zeptosecond measures things in terms of the speed of light. It is difficult for the human mind to understand these measurements. One millisecond is a thousandth of one second. This is the time for a neuron in the human brain to fire. One nanosecond is one billionth of one second. The shortest unit of time it may be possible to measure is one Planck. This is a decimal point followed by 44 zeros and a 1.

Taken from https://breakingnewsenglish.com/2010/201020-zeptosecond.html

UNIT 2. BIOPHYSICS

BIOCHEMISTS AND BIOPHYSICISTS CAREER

Researching and new medical cure, unlocking DNA secrets or developing a more resilient variety of wheat… Biochemists and biophysicists study living things and the processes that make them grow, change and die. These scientists design and conduct experiments, such as testing the effects of drugs, or learning how different cells divide and grow. They may study evolution in plants and animals, nerve cell communication, or how proteins work. Advanced technology is often used on the job, including lasers and fluorescent microscopes.

Biophysicists and biochemists prepare technical reports and research papers, and may make recommendations to a research sponsor. They also may lead laboratory teams and ensure the quality of their work. Conducting scientific experiments takes accuracy and precision, as well as strong maths skills, good judgment, and perseverance. The ability to communicate and work with a team is just as essential for these scientists.

Biochemists and biophysicists typically work in laboratories to conduct experiments and in offices to analyze the results. Most work full time and keep regular hours. Employers include research and development companies, higher education, and pharmaceutical manufacturing.

Biochemists and biophysicists need a PhD to work in independent research and development position. Some entry-level positions may be obtained with a bachelor's or master's degree in the field.

HOW DOES A SPECTROPHOTOMETER WORK?

This short animation demonstrates the inner workings of a spectrophotometer.

Here's how a spectrophotometer works. A lamp provides the source of light. The beam of light strikes the diffraction grating, which works like a prism and separates the light into its component wavelengths. The grating is rotated so that only a specific wavelength of light reaches the exit slit. Then the light interacts with the sample. From this point, the detector measures the transmittance and absorbance of the sample. Transmittance refers to the amount of light that passes completely through the sample and strikes the detector. Absorbance is a measurement of light that is absorbed by the sample. The detector senses the light being transmitted through the sample and converts this information into a digital display.

UNIT 3. OPTICS AND HOLOGRAPHY

HOLOGRAMS: WHAT IS POSSIBLE IN THE NEAR FUTURE?

Let’s talk about the elephant in the room. Is it a hologram? German circus Roncalli has a new treat for its visitors, its animals are digitally rendered projections, the computer-generated piece displayed on a thin transparent screen. The holographic circus is a great idea. That way the wild animals are being spared from being carted around in cages. But what exactly are holograms? Could we use them for communication and what does the future hold in store for them? Let’s have a look at the definition. A hologram is an image that appears to the naked eye to be three-dimensional. Images that require the aid of special glasses or other intermediaries are often incorrectly called holograms. Real holograms are created in a rather complicated process using lasers so our elephant is not really a hologram. Although the term is nowadays used for all kinds of technologies that look similar to the communication systems in Star Wars and our great friend here is no great novelty, either the idea has been especially popular in the live music industry. For quite some time we’ve seen the cartoon band Gorillaz on tour, later rapper 2pac being digitally resurrected for a stage appearance and Japanese anime popstar Hatsune Miku has been selling out big venues in her homeland. But compared to real holograms, these examples are somewhat underwhelming. Basically, they are simply two-dimensional projections onto a transparent screen scene. From enough of a distance though, they can look rather real. Wouldn’t it be great if we could use 3d holograms to communicate with our friends abroad? Sure, and the tech industry is busy finding solutions to make that possible but for now there are technical limitations. The classic hologram created with the use of lasers has one striking characteristic – it’s incredibly detailed. Now if you want to translate that to digital terms that means you need a lot of data even if it took a rather simplified 3D version of me, for example, we’d need a lot more data than would be required for a current video call. Apart from that for a 3D representation of myself I need recording devices that capture me from all angles. I had myself 3D printed some time ago; it is the result the studio in which it was taken using 48 cameras. Installing a similar studio in my apartment the cost of space related aspects would make it a no deal. Projectors are a big hurdle. Two scientists have already developed systems that work without the use of screens to create real 3D images simply putting they use particles in the air to reflect laser beams but devices like these are much too massive and too expensive for the general market and then the third problem. Our mobile internet is quite simply too slow to transfer the large amounts of data necessary for a holographic chat. Developers have high hopes for the new mobile communication standard 5G networks can transfer huge amounts of data at incredible speed making things like holographic chats more achievable. If you want to learn more about 5G check out this video. Here this opens up a whole new world of opportunities. Let's suppose you lived in Mumbai and had a sales pitch in New York, for example, you could do it without flying. Cameras in a studio in your home location could capture your actions and then transmit them to New York while you could see the people attending the pitch via a video stream and interact with them in real-time. Sounds like science fiction some companies already offer such a service so be prepared for conference rooms full of holograms in the future while this might not be much cheaper than flying yet it will definitely improve your carbon footprint. Microsoft is taking this idea even one step further with the help of AI software they want to create 3D avatars of people that can be displayed over augmented reality goggles using avatars and Microsoft's HoloLens system might seem a little uncanny but it has one huge advantage using the right software good digitally represent could speak any language you want it, Japanese, for example, as Microsoft recently presented what does your new home, now bear in mind as mentioned before these two examples aren't technically speaking really holograms but this one could be reported. Samsung has patented a technology that lets a smartphone project high-quality 3D images into thin air without you needing to look at the display from any specific angle. It will supposedly be able to use an array of special lenses to help focus a beam of light being emitted from the display that really would come very close to the holographic communicators used in Star Wars. Too good to be true, probably, but let's wait and see. The tech industry is working hard on Holograms and just might come up with some stunning solutions very soon. What do you think of digital holograms? Useful future technology or another gimmick that makes us buy more gadgets? Let us know in the comments and if you've got a digital topic, you'd like us to cover let us know as well hope you enjoyed this video. Bye!

HOLOGRAM SECURITY STICKER AND SECURITY PRINTING

In modern times though governments and other organizations have used technology to finally start to seriously combat the ancient practices of forgery and counterfeiting. So, what are some of the things that make documents like passports, driver's licenses, credit cards, and cash so hard to forge these days? Let's start with something that's usually pretty easy to see – the hologram. Because a hologram is really a precise record of how light diffracts off of an object at different angles, it's harder to produce than a regular photograph. You need lasers lenses and special film making. This is a popular security feature on ID cards, credit cards, and passports. But of course, holograms can still be copied, given the right tools. So, these days you might also see very fine engraving in the hologram, if you look closely enough, which is even more difficult to copy if you don't have the same equipment that was originally used to make it but rather the special inks that are used for printing money or other documents. Oftentimes governments can defeat people that try to modify passports illegally by printing them with thermally sensitive ink when the forger tries to tamper with the passport, a process that often requires heat the ink will change colour, letting officials know that passport is no longer kosher. There are also inks that can be printed in two and a half dimensions. So, you can actually feel a bump with your finger ones that shift colour depending on the viewing angle. This is a pretty neat feature of the latest us currency and even ones that shine under a black light.

UNIT 4. NANOTECHNOLOGIES

IMPACTING THE WORLD WITH NANOTECHNOLOGY: A CONVERSATION WITH CHAD MIRKIN

Introduction [LISA] Welcome to a special 15-year anniversary episode of Stories from the NNI. I'm Lisa Friedersdorf, Director of the National Nanotechnology Coordination Office. Today it's my pleasure to welcome Chad Mirkin, Professor and Director of the International Institute for Nanotechnology at Northwestern University. Chad is one of the few scientists to be elected to all three US National Academies, medicine, science, and engineering. Chad is a well-known nanoscientist. He is also the founder of several companies which are actively commercializing nanotechnology applications in the life science and semiconductor industries. Chad, thank you so much for being with us today. To get Who is Chad Mirkin things started, could you tell us a little bit about yourself and how you first got involved in nanotechnology? [CHAD] Sure. I started out as a chemist. I was trained as a synthetic organometallic chemist at Penn State. I moved to MIT to do a postdoc where I learned a little bit about surface science and electrochemistry. I worked for a really famous guy at the time, a guy named Mark Wright and who was interested in consequences of miniaturization. He was a little bit ahead of his time. At that time, we were looking at micro-scale systems. And I was pretty much at the right place at the right time with the the nanotech revolution when I started my independent career at Northwestern University. And it was clear that there was tremendous interest in first miniaturized chemical systems at the time, but this idea that matter behaves very differently when you shrink it down to the sub 100 nanometer length scale. And the first tools for manipulating matter on that scale were becoming commercial. Things like atomic force microscopes, scanning tunneling microscopes. And I thought I should go learn how to use some of these tools and I went to a facility and effectively self-taught myself how to use an AFM. And pretty soon we were developing all sorts of new capabilities based upon these tools and thinking about developing the field, the modern field of nanoscience through primarily chemistry driven approaches. [LISA] So you mentioned developing capabilities How does nanotechnology play a role in enabling technologies and you’ve developed nanoparticle-based bio diagnostics and therapeutic tools. How does nanotechnology play a role in enabling these technologies? [CHAD] Look, nanotech I think is important for many technologies. We’ve really had a major focus on biomedical, but anywhere where new materials are important nanotech is going to play a role. And the reason I say that is everything old becomes new when shrunk to the sub 100 nanometer length scale. Any material that you have, if you shrink it down to this scale it takes on new properties. And a lot of the science is about figuring out what those properties are and how they relate to the particular structure that you have, but the applications are driven by those new properties that you discover. In the area of biodiagnostics we learned very early on that when you take gold nanoparticles and decorate them with oligonucleotide strands and high-density, you create a new structure that we now refer to as a spherical nucleic acid structure and has really unusual 3:05 properties. Properties that are very different from the linear nucleic acids 3:09 from which it derives. Different from, in fact, even the gold particle core alone. And one of those is the ability to bind to complementary targets with very high affinity. And so that property becomes the basis for very sensitive labels for different nucleic acid signatures of disease. We quickly developed a whole 3:30 series of new assays based upon these types of particles as probes that soon became commercial assays. And in fact the the VERIGENE system that’s sold by Luminex, which is for point-of-care medical diagnostics, is now in half the world's top hospitals and used quite heavily for disease diagnosis. Exciting developments over the past 20 years [LISA] Could you share some exciting developments over the past 20 years or where you have seen your work build upon itself and evolve into new areas? [CHAD] So that’s a great question because we just had a really big discovery that was reported in *Science* literally last week. If you go back two decades ago, our lab’s fairly well-known for inventing what we like to refer to as the world’s smallest pen. At the time, which was 1999, we discovered that you could use an atomic force microscope to locally control chemistry between tip and surface taking advantage of what many people in the field viewed as a problem, but we turned into a major plus, which was water collects at the point of contact between tip and surface and that water sucks the tip down and convolutes any sort of measuring you make there after. We’ve even got water as a solvent that’s involved in a chemical reaction. You can begin to use it to your advantage to pattern materials on a surface with a resolution of an AFM, hence the world’s smallest pen. Over the course of the next decade, we actually developed it into a tool that used up to hundreds of thousands of pens to pattern in parallel, and then we even commercialized many of those instruments and those are used for research purposes all around the world in many different research labs, both in universities and in industry.

NANOTECHNOLOGY EXPERT EXPLAINS ONE CONCEPT IN 5 LEVELS OF DIFFICULTY

- Hi, I’m George Tulevski, and I’m a research scientist at IBM TJ Watson Research Center. Today I’ve been challenged to teach one concept in five levels of increasing complexity. And my topic is nanotechnology. Nanotechnology is a study of objects in the nanoscale between 1 and 100 nanometers in size. And it turns out that objects in this size scale have really interesting properties that differ from objects at a macroscopic scale. Our task is nanotechnologists is to understand these materials, understand their properties, and then try to build new technologies based on these properties. At the end of the day, my hope is that you’ll understand nanotechnology at some level. What is nanotechnology Hi, are you Bella? - Yes. - Bella, I'm George, nice to meet you. - Nice to meet you too! – I’m a research scientist. Do you like science? - Yeah. - I wanted to talk to you about a specific type of science called nanotechnology. Have you ever heard of this word before? - Nhn nhn. - Nano is kind of a funny word, right? It’s a word that’s used before another word, and it means one billion. What’s the smallest object you can think of? - A baby ant? - A baby ant? Very good. So, I have over here a meter stick, let me show it to you. And so that’s a meter and if I divide it by 1000, I get a millimeter. So milli just means 1000. There are all these little lines on the ruler. And each of those little lines is one millimeter. So, a baby ant is probably a couple of millimeters. So even the thing, that’s the smallest thing you can think of, it’s a million times bigger than a nanometer. Tiny, tiny, tiny. - Tiny, tiny, tiny, tiny. - If I took this stick and I was to draw 1 billion lines, the distance between those two lines would be one nanometer. So that’s really all it is. It’s just a measure of size. But it’s really, really, really tiny, smaller than anything that we can see with our eyes. The reason why, in nanotechnology, scientists, we care about things that are that small, is because there are objects called atoms. Have you ever heard of atoms before? - Yes. I first heard of them on a show I watched called “StoryBots.” They’re just little things that make up everything on Earth, even earth. - That was a perfect explanation. But what if I told you that scientists invented a special type of microscope that not only lets you see atoms, but also lets you move them around and build things with them. Would you think that would be pretty cool? - Yeah! – So, it’s called a scanning tunneling microscope. And not only can you see the atoms, but you can move them around. Atoms are kind of sticky. You can actually build things using this instrument with actual individual atoms. So, if I gave you that machine, would you want to make something? Would you want to look at something very carefully? - I would want to make a unicorn out of atoms. - You are definitely a second grader! [laughing] My daughter would probably answer the exact same way. A unicorn would be awesome. - Why do you study stuff so small? - I study it because objects that are that small have really interesting properties. They behave completely different than objects that are big. And because of that, we can build really cool things with them. Like really fast computers, for example, or new types of batteries or new types of solar cells. And a lot of nanotechnology is kind of like playing with Legos. You take these small objects and you put them together to build something new. Something interesting that no one’s built before. It’s like Legos for scientists. - Cool. [light music] How does nanotechnology work – So, how old are you? – I’m 16. - 16. So, what is that, you're in 10th grade? - Junior year. So, 11th grade. - Have you of nanotechnology? Have you heard of this term before? - Yeah, I’ve heard of it. - What do you think of when you think of nanotechnology? - It kind of seems very science fiction.

UNIT 5. ACOUSTICS
SUN'S SOUNDS

What does the Sun sound like? Perhaps you have never thought about what kinds of sounds the Sun makes, but scientists have found out. Researchers from the European Space Agency, NASA and the Solar and Heliospheric Agency studied 20 years of data to listen to the Sun. They say the Sun produces a low, deep "heartbeat" sound. The scientists used a solar observatory to measure vibrations from the Sun. They translated these vibrations into different sounds. These can tell the scientists what is happening inside the Sun. They can now understand more about solar flares, chemical reactions and other phenomena that happen inside the Sun and on its surface.

The scientists explained how they created the Sun's sound. Researchers from the Stanford Experimental Physics Lab turned data from the space agencies into a "song". Dr Alex Young said: "We don't have straightforward ways to look inside the Sun. We don't have a microscope to zoom inside the Sun, so using a star or the Sun's vibrations allows us to see inside of it." Dr Young continued: "Waves are travelling and bouncing around inside the Sun, and if your eyes were sensitive enough, they could actually see this." He added: "We are finally starting to understand the layers of the Sun and the complexity. That simple sound is giving us a probe inside a star. I think that's a pretty cool thing."

Taken from https://breakingnewsenglish.com/1807/180729-sounds-of-the-sun.html

HOW SOUND WORKS (IN ROOMS)

Hi, I'm John Calder of Acoustic Geometry. Let's talk about acoustics, which is basically how sound works in rooms. It may seem complicated, so let's make it simpler!

Most rooms have flat walls and flat ceilings, and sound bounces off of these. So how does that affect the sound? I'll use these two nerf guns to demonstrate. I've got this one aimed, so this disk goes directly to the ear that represents direct sound. I've got this one aimed, so that disk bounces off the wall and it represents reflected sound.

I'll shoot them both at the same time. Reflected sound arrives at our ears later than direct sound, even though it started out at the same time, because it's traveling farther. And this wall is only one flat surface. There are at least 6 in the average room and that's a lot of reflected sound.

But why is reflected sound bad? I'll demonstrate using these two identical patterns. The blue pattern represents direct sound waves. The red pattern represents reflected sound waves. They start out together, but when I move the red one backwards, like a delayed sound reflection, it creates destructive interference patterns which change the original sound wave.

Here's the problem. Original sound waves are distorted by strong later-arriving reflections. Also, sound travels really fast – about 1130 feet per second. A sound wave will bounce back and forth between these two walls about 60 times in one second. Sound travels so fast that it fills a room almost instantly. This is only one bounce angle, every room has thousands.

How can we make our rooms sound better? Remember our nerf guns? I'll shoot these at the same time, again representing a sound wave bouncing off a wall. Both discs bounce together in the same direction, which means the reflected sound is at full strength. Now let's use the first of our two acoustical tools, an absorber, to reduce the strength of sound bounces. To a sound wave, an absorber looks a little like a hole in the wall, so some of the energy doesn't come back. An absorber works by reducing the strength of reflected sound that would otherwise cause more destructive interference. But if we use only absorbers in a room, it makes it sound dull and unnatural. Historically, humans don’t like overly absorbent rooms.

So, let’s use the second of our two acoustical tools, the curved surface diffusor. It also reduces the strength of sound bounces. A diffusor works by scattering the sound reflections in different directions, smoothing out destructive interferences throughout the room. Room acoustics are greatly improved using a combination of absorption and diffusion.

It’s all about reducing those flat-surface reflections. Use a combination of absorbers and diffusors and your room will sound a lot more natural.

Taken from https://www.youtube.com/watch?v=JPYt10zrclQ&ab_channel=AcousticGeometry

APPENDIX 5. PROBLEM SOLVING

UNIT 1. PARTICLE PHYSICS

Particle Physics Quiz

1. Which of the following particle is responsible for carrying away the missing energy and momentum in a nuclear decay process.

   A. Alpha-particle

   B. Neutrino

   C. Lepton

   D. Proton

2. Who of the following scientists were responsible for the first splitting of a nucleus by artificially accelerated particles?

   A. Isaac Newton

   B. John Cockroft

   C. Ernest Walton

   D. Alfred Einstein

3. Which group of particles do not feel the strong the force?

   A. Alpha-particles

   B. Neutrinos

   C. Leptons

   D. Protons

4. Which of the following particles are Hadrons?

   A. Electron

   B. Proton

   C. Muon

   D. Sigma

5. The anti-particle of the Electron is called the _______________ (positron)

6. In Pair Annihilation, a particle and its anti-particle join to be annihilated and produce two of these. What are they?

A. Protons
B. Gamma Rays
C. X-Rays
D. Photons

7. How many quarks are there?

A. 2
B. 4
C. 6
D. 8

8. What type of particle is made up of a quark and its anti-quark? ___________

9. The name “quark” was first used by Gell-Mann, but it came from a quotation from which of the following authors?

A. William Shakespeare
B. James Joyce
C. W. B. Yeats
D. Thomas Elliot

10. Which of the following are elementary particles?

A. Lepton
B. Proton
C. Electron
D. Tao

Taken from http://homepage.eircom.net/~louiseboylan/Pages/test.htm

UNIT 2. BIOPHYSICS

A Star Wars Quiz

Words for a galaxy far, far away…

Whether you're a dedicated contributor to Wookieepedia or just proud of yourself for knowing what a Wookiee is, there are some great words at work in a galaxy far, far away. Take the quiz, and challenge yourself to expand your Star Wars vocabulary!

1. Anakin and Luke Skywalker are from Tatooine. A planet with two suns is called:

A. a quasi-satellite planet

B. an ecliptic planet

C. a circumbinary planet

D. an elliptical path

2. Do you know what a "galaxy" is?

A. any of the heavenly bodies, except the moon, appearing as fixed luminous points in the sky at night

B. a large system of stars held together by mutual gravitation and isolated from similar systems by vast regions of space

C. the totality of known or supposed objects and phenomena throughout space; the cosmos; macrocosm

D. the curved path, usually elliptical, described by a planet, satellite, spaceship, etc., around a celestial body, as the sun

3. What's this starfighter called?

A. TAI fighter - two angled induction

B. TIE fighter - twin ion engine

C. TAI fighter - trans-astronomical induction

D. TIE fighter - tactical interstellar energizer

4. ‘Empire’ also has many definitions – which of these isn't one of them?

A. an aggregation of persons of the same ethnic family, often speaking the same language or cognate languages

B. a government under an emperor or empress

C. supreme control; absolute sway

D. a powerful and important enterprise or holding of large scope that is controlled by a single person, family, or group of associates

5. A ‘parsec’ is:

A. one thousandth of a second; one thousand microseconds

B. an indefinitely short space of time

C. a unit of distance equal to that required to cause a heliocentric parallax of one second of an arc, equivalent to 3.26 light-years

D. the absolute value of the maximum displacement from a zero value during one period of an oscillation

6. What does pluto mean?

A. Wealthy

B. Dog-like

C. Cold

D. Radioactive

7. Which of these goes between different states?

A. Intrastate

B. Interstate

C. Intra-state

D. Inter-state

8. What does supra- mean?

A. Below

B. Above

C. Extraordinary

D. Mediocre

9. Which of these is spelled correctly?

A. Misspell

B. Mis-spell

C. Mispell

D. Miss-spell

10. They're so excited for their ______ road trip.

A. tranamerican

B. trans-American

C. transamerican

D. tran-american

11. If you mean ‘cover again,’ which of these is right?

A. Precover

B. Procover

C. Recover

D. Re-cover

12. Have a _____ ice cream.

A. selfcongratulating

B. self-congratulating

C. self-congratulatory

D. selfcongratulatory

UNIT 3. OPTICS AND HOLOGRAPHY

Optics and Holography Quiz

1. Originally, the term optics was used only in relation to:

   A. the eye and vision

   B. different types of lenses

   C microscopes

2. Spectroscopy is a study of:

   A. the genesis and propagation of light

   B. the apparent reproduction of an object by a lens or mirror system

   C. the absorption and emission of light and other radiation by matter

3. *Laser* is an … for “light amplification by the stimulated emission of radiation.”

   A. abbreviation

   B. acronym

   C. contraction

4. In the … , Valerie Thomas invented a way to transmit three-dimensional images, or holograms, that appear to be real, which led to her invention of the “illusion transmitter,” for which she received a patent.

   A. 1960s

   B. 1970s

   C 1980s

5. Three-dimensional vision in reverse is called:

   A. Pseudoscopic vision

   B. Bipolar vision

   C. Astigmatism

6. The mirrors used in Greco-Roman antiquity and throughout the European Middle Ages were simply slightly convex disks of metal, either bronze, tin, or silver, that reflected light off their highly polished surfaces. A method of backing a plate of flat glass with a thin sheet of reflecting metal came into widespread production in … during the 16th century.

   A. Paris

B. Venice

C. Istanbul

7. The word optics is derived from the Greek term τα ὀπτικά meaning:

A. ‘appearance, look’

B. glass

C. vision

8. **aberration**, in optical systems, such as lenses and curved mirrors, the deviation of light rays through lenses, causing images of objects to be ….

A. blurred

B. distorted

C. twisted

9. Each colour of light has its own wavelength.

A. True

B. False

10. There are … of colours in a rainbow.

A. dozens

B. hundreds

C. thousands

UNIT 4. NANOTECHNOLOGIES

Nanotechnologies Quiz

1. What is nanotechnology?
   A. The study of atoms and electrons
   B. The study of very small particles and their manipulation at the nanoscale
   C. The study of bacteria
2. Which of the following is NOT a unit of measurement for nanotechnology?
   A. Nanometer
   B. Micrometer
   C. Millimeter
3. Which Nobel Prize-winning physicist introduced the concept of nanotechnology in a 1959 talk titled “There’s Plenty of Room at the Bottom”?
   A. Richard Feynman
   B. Marie Curie
   C. Niels Bohr
4. The prefix “nano” is derived from the Greek word “nanos,” which means:
   A. Big
   B. Small
   C. Fast
5. What is the size range of nanoparticles in nanotechnology?
   A. 1 to 100 millimeters
   B. 1 to 100 micrometers
   C. 1 to 100 nanometers
6. Which of the following fields has NOT been significantly impacted by nanotechnology?
   A. Electronics
   B. Agriculture
   C. Archaeology

7. The process of using nanoparticles to deliver drugs directly to targeted cells in the body is called:
   A. Nanocomputing
   B. Nanotargeting
   C. Nanomedicine
8. Carbon nanotubes are known for their exceptional strength and are commonly used in which industry?
   A. Textile manufacturing
   B. Construction
   C. Aerospace and materials science
9. What unique property of nanoparticles gives them enhanced reactivity and makes them suitable for catalytic applications?
   A. Low surface area
   B. Low surface-to-volume ratio
   C. High surface area
10. The self-assembly of nanoparticles into organized structures is often inspired by which natural phenomenon?
   A. Erosion
   B. Volcanic eruptions
   C. Crystal formation

UNIT 5. ACOUSTICS

Acoustics Quiz

1. Elements of acoustic, except for?

   A. Sound source

   B. Sound transmission path

   C. Sound receiver

   D. Sound subdivision

2. The intensification and prolongation of sound produced by sympathetic vibration?

   A. Echo

   B. Resonance

   C. Loudness

   D. Volume

3. A driving force in tune with the natural frequency?

   A. Echo

   B. Resonance

   C. Phon

   D. Volume

4. A unit of loudness level?

   A. Phon

   B. Volume

   C. Amplitude

   D. Loud

5. Amplitude is a function of the sound wave's loudness of the sound pressure.

   A. True

   B. False

6. If a sound can travel between concrete walls, can it travel under the water?

   A. Yes

   B. No

7. The number of occurrences of a repeating event per unit time?
   A. Sound cycle
   B. Frequency
   C. Wavelength
   D. Echo

8. The "persistence" of sound in a particular space after the original sound is produced?
   A. Echo
   B. Reverberation
   C. Sound reflections
   D. Vibration

9. The range of sound a human ear can detect?
   A. 20-20,000 Hz
   B. 100-30,000 Hz
   C. 200-76,000 Hz
   D. 45-64,000 Hz

10. What is an octave?
    A. An alternate pitch with half of its frequency is alternate and doubled
    B. Interval between one musical pitch and another with half or double its frequency
    C. A harmonic series of 8 pitch of sound in 1 single frequency
    D. Perceptual property that allows the ordering of sounds on a frequency related scale

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