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AKADEMIK LITSEYLARDA NEMIS TILINI O'QITISHDA RAQAMLI TA'LIM RESURLARINING O'RNI

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Termiz davlat universiteti akademik litseyi nemis tili fani o'qituvchisi

Annotatsiya: Mazkur maqolada akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslarining o'rni va ahamiyati tahlil qilingan. Tadqiqotda elektron darsliklar, multimedia vositalari, onlayn platformalar hamda mobil ilovalarning ta'lim jarayonidagi didaktik imkoniyatlari yoritilgan. Shuningdek, raqamli texnologiyalardan foydalanishning o'quvchilarning kommunikativ kompetensiyasi, mustaqil ta'lim ko'nikmalari va ta'lim samaradorligini oshirishdagi ahamiyati ochib berilgan.

Kalit so'zlar: nemis tili, raqamli ta'lim resurslari, akademik litsey, axborot-kommunikatsiya texnologiyalari, multimedia, onlayn platformalar, kommunikativ kompetensiya, interfaol ta'lim, elektron darslik, masofaviy ta'lim.

Bugungi kunda ta'lim tizimini raqamlashtirish jarayoni jadal sur'atlar bilan rivojlanib, chet tillarini o'qitishda ham yangi imkoniyatlarni yaratmoqda. Axborot-kommunikatsiya texnologiyalarining ta'lim jarayoniga keng joriy etilishi o'quvchilarning bilim olish samaradorligini oshirish, mustaqil ta'lim ko'nikmalarini rivojlantirish hamda o'qitish sifatini takomillashtirishga xizmat qilmoqda. Ayniqsa, akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslaridan foydalanish o'quvchilarning til o'rganishga bo'lgan qiziqishini kuchaytirish bilan birga, ularning kommunikativ kompetensiyalarini rivojlantirishda muhim omil hisoblanadi.

Raqamli ta'lim resurslari tarkibiga elektron darsliklar, multimediy vositalari, mobil ilovalar, onlayn platformalar, virtual laboratoriyalar hamda sun'iy intellekt asosidagi dasturlar kiradi. Ushbu vositalar ta'lim jarayonini interaktiv tashkil etish, tinglab tushunish, o'qish, yozish va gapirish ko'nikmalarini samarali shakllantirish imkonini beradi. Shuningdek, o'quvchilarning individual xususiyatlarini hisobga olgan holda tabaqalashtirilgan ta'limni tashkil etishga yordam beradi.

Akademik litseylarda nemis tilini o'qitish jarayonida zamonaviy raqamli texnologiyalardan foydalanish nafaqat ta'lim sifati va samaradorligini oshiradi, balki o'quvchilarni xalqaro axborot makoniga integratsiyalashuviga ham xizmat qiladi. Shu sababli nemis tilini o'qitishda raqamli ta'lim resurslarining didaktik imkoniyatlarini o'rganish va amaliyotga tatbiq etish dolzarb ilmiy-pedagogik masalalardan biri hisoblanadi.

Chet tillarini o'qitishda raqamli ta'lim resurslaridan foydalanish masalasi so'nggi yillarda pedagogika va metodika sohasidagi dolzarb tadqiqot yo'nalishlaridan biriga aylandi. Mahalliy va xorijiy olimlarning ilmiy izlanishlarida axborot-kommunikatsiya texnologiyalarining ta'lim jarayoniga integratsiyalashuvi o'quvchilarning bilish faolligini oshirish, mustaqil ta'lim ko'nikmalarini rivojlantirish hamda ta'lim samaradorligini yuksaltirishga xizmat qilishi ta'kidlangan. Xususan, nemis tilini o'qitishda elektron



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darsliklar, multimedia vositalari, videodarslar, mobil ilovalar va onlayn platformalardan foydalanish til kompetensiyalarini rivojlantirishda muhim vosita sifatida e'tirof etiladi.

Ilmiy manbalarda qayd etilishicha, raqamli ta'lim resurslari o'quvchilarning tinglab tushunish, o'qish, yozish va gapirish ko'nikmalarini kompleks ravishda rivojlantirish imkonini beradi. Ayniqsa, interaktiv mashqlar, virtual muloqot muhiti va masofaviy ta'lim platformalari o'quvchilarning chet tilini amaliy qo'llash tajribasini boyitadi. Nemis tilini o'qitishda zamonaviy texnologiyalardan foydalanish o'quvchilarning darslarga bo'lgan qiziqishini oshirishi, ta'lim jarayonini individuallashtirish va differensiallashtirishga xizmat qilishi ko'plab tadqiqotlarda asoslab berilgan.

Mazkur tadqiqotda akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslarining o'rni va ahamiyati nazariy hamda amaliy jihatdan tahlil qilindi. Tadqiqot jarayonida pedagogik kuzatish, ilmiy adabiyotlarni tahlil qilish, qiyosiy tahlil, umumlashtirish va tizimlashtirish metodlaridan foydalanildi. Shuningdek, nemis tili darslarida qo'llanilayotgan zamonaviy raqamli platformalar, elektron ta'lim vositalari va multimedia texnologiyalarining ta'lim samaradorligiga ta'siri o'rganildi.

Tadqiqotning metodologik asosini ta'limni raqamlashtirish, kompetensiyaviy yondashuv hamda interfaol ta'lim texnologiyalariga oid ilmiy qarashlar tashkil etdi. Olingan ma'lumotlar tahlili asosida akademik litseylarda nemis tilini o'qitish jarayonida raqamli ta'lim resurslaridan foydalanishning pedagogik imkoniyatlari va istiqbollari yoritib berildi.

Tadqiqot davomida akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslaridan foydalanishning pedagogik imkoniyatlari tahlil qilindi. O'rganishlar shuni ko'rsatdiki, zamonaviy axborot-kommunikatsiya texnologiyalarining ta'lim jarayoniga keng joriy etilishi o'quvchilarning chet tilini o'zlashtirish darajasini oshirishga xizmat qilmoqda. Xususan, elektron darsliklar, multimedia taqdimotlari, videodarslar, mobil ilovalar va onlayn ta'lim platformalari nemis tilini o'rganish jarayonini yanada qiziqarli va samarali tashkil etish imkonini bermoqda.

Raqamli ta'lim resurslaridan foydalanish o'quvchilarning darsdagi faolligini oshirishi aniqlandi. An'anaviy darslarda o'quvchilar asosan o'qituvchi tomonidan berilgan ma'lumotlarni qabul qiluvchi sifatida ishtirok etsa, raqamli texnologiyalar qo'llanilgan darslarda ular mustaqil izlanish olib boruvchi, axborotni tahlil qiluvchi va amaliy topshiriqlarni bajaruvchi faol subyektga aylanadi. Bu esa ta'limning samaradorligini oshirish bilan bir qatorda o'quvchilarning tanqidiy va ijodiy fikrlash ko'nikmalarini rivojlantiradi.

Nemis tili darslarida multimedia vositalaridan foydalanish ayniqsa tinglab tushunish va talaffuz ko'nikmalarini shakllantirishda muhim ahamiyat kasb etadi. Audio va video materiallar yordamida o'quvchilar nemis tilidagi tabiiy nutqni eshitish, so'zlarning to'g'ri talaffuzini o'rganish hamda real muloqot vaziyatlari bilan tanishish imkoniyatiga ega bo'ladilar. Natijada o'quvchilarning eshitish orqali axborotni qabul qilish qobiliyati va og'zaki nutq faolligi sezilarli darajada rivojlanadi.

Tadqiqotlar davomida onlayn platformalarning ham nemis tilini o'qitishdagi ahamiyati yuqori ekanligi kuzatildi. Xususan, masofaviy ta'lim elementlari, virtual



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topshiriqlar, elektron testlar va interaktiv mashqlar o'quvchilarning bilimlarini muntazam nazorat qilish hamda mustahkamlash imkonini beradi. Bunday vositalar ta'lim jarayonini individuallashtirishga yordam berib, har bir o'quvchining bilim darajasi va ehtiyojlariga mos topshiriqlarni bajarishiga sharoit yaratadi.

Raqamli ta'lim resurslarining yana bir muhim jihati shundaki, ular o'quvchilarda mustaqil ta'lim kompetensiyasini shakllantiradi. O'quvchilar internet manbalari, elektron kutubxonalar va ta'lim platformalari orqali qo'shimcha ma'lumotlarni izlash, tahlil qilish va ulardan foydalanishni o'rganadilar. Bu esa ularning nafaqat til o'rganish jarayonidagi, balki kelgusidagi kasbiy faoliyatidagi muvaffaqiyatlariga ham ijobiy ta'sir ko'rsatadi.

Shu bilan birga, raqamli texnologiyalardan foydalanish jarayonida ayrim muammolar ham mavjud. Jumladan, texnik vositalarning yetarli emasligi, internet tezligining pastligi yoki ayrim o'qituvchilarning raqamli kompetensiyasi talab darajasida shakllanmaganligi ta'lim samaradorligiga salbiy ta'sir ko'rsatishi mumkin. Biroq ushbu muammolarni bartaraf etish orqali raqamli ta'lim resurslaridan foydalanish imkoniyatlarini yanada kengaytirish mumkin.

Umuman olganda, olib borilgan tahlillar akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslaridan foydalanish ta'lim sifatini oshirish, o'quvchilarning kommunikativ kompetensiyasini rivojlantirish, mustaqil ta'lim faoliyatini qo'llab-quvvatlash hamda zamonaviy ta'lim muhitini shakllantirishda muhim omil ekanligini ko'rsatdi.

Akademik litseylarda nemis tilini o'qitishda raqamli ta'lim resurslaridan foydalanish ta'lim jarayonining samaradorligini oshirishda muhim ahamiyat kasb etadi. Tadqiqot natijalari shuni ko'rsatdiki, elektron darsliklar, multimedia vositalari, onlayn platformalar va mobil ilovalar o'quvchilarning nemis tilini o'zlashtirish darajasini oshirish, ularning darslarga bo'lgan qiziqishini kuchaytirish hamda kommunikativ kompetensiyalarini rivojlantirishga xizmat qiladi.

Raqamli texnologiyalar yordamida ta'lim jarayonini interaktiv tashkil etish, o'quvchilarning mustaqil ta'lim faoliyatini qo'llab-quvvatlash va bilimlarni nazorat qilish imkoniyatlari kengayadi. Ayniqsa, tinglab tushunish, o'qish, yozish va gapirish ko'nikmalarini rivojlantirishda raqamli resurslarning samaradorligi yuqori ekanligi aniqlandi.

Shuningdek, raqamli ta'lim vositalaridan foydalanish o'quvchilarning axborot bilan ishlash, tahlil qilish va zamonaviy texnologiyalardan samarali foydalanish kompetensiyalarini shakllantirishga yordam beradi. Bu esa ularning kelajakdagi ta'lim va kasbiy faoliyatida muhim ahamiyat kasb etadi.

Xulosa qilib aytganda, akademik litseylarda nemis tilini o'qitish jarayoniga raqamli ta'lim resurslarini keng joriy etish ta'lim sifatini oshirish, o'quvchilarning bilim va ko'nikmalarini mustahkamlash hamda zamonaviy ta'lim talablariga mos raqobatbardosh mutaxassislarni tayyorlashning muhim omillaridan biri hisoblanadi.

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PROSPECTS FOR ENSURING ECOLOGICAL SECURITY IN CENTRAL ASIA

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Abstract: This article analyzes the issue of ecological security in Central Asia from historical, political, and ecological perspectives. It examines the ecological consequences of Soviet-era irrigation and agrarian policies, the Aral Sea disaster, challenges in managing transboundary water resources, desertification and biodiversity loss, the impact of climate change on regional ecosystems, and ecological migration processes. Particular attention is devoted to Uzbekistan's ecological policy during the years of independence, the initiatives of President Shavkat Mirziyoyev, and the country's activities within the framework of international ecological diplomacy. The article emphasizes that ensuring ecological security requires regional cooperation, the strengthening of applied scientific research, and the mobilization of international financial resources.

Keywords: Ecological security, Central Asia, Aral Sea crisis, Water resources, Desertification, Climate change, Biodiversity, Ecological migration, Ecological diplomacy, Uzbekistan's initiatives, IFAS (International Fund for Saving the Aral Sea), Sustainable development

1. Introduction

Since the second half of the twentieth century, ecological security has emerged as one of the priority directions of international politics. In this regard, Central Asia occupies a particularly significant position: on the one hand, the region is historically shaped by an irrigation-based civilization, while on the other, the misguided agrarian and industrial policies implemented during the Soviet era generated profound ecological crises in the area. Today, the complex of problems ranging from the tragedy of the Aral Sea to the new threats posed by climate change has transformed Central Asia into a focal point of global dialogue on ecological security.

This article examines the regional meaning of the concept of ecological security, the historical roots and stages of ecological problems, as well as the ecological diplomacy and prospective solutions pursued by Uzbekistan and neighboring states from an analytical perspective. The methodological foundation of the study rests on the principles of historicism, comparative analysis, systems thinking, and cause-and-effect methodology.

2. Main Section

The term "*ecological security*" was first officially introduced in the 1987 report of the UN Brundtland Commission, where it was defined as a condition of the natural environment in which the essential ecosystem services required for human survival and societal development are continuously maintained¹. In the context of Central Asia, this

¹ Karimov I.A. O'zbekiston buyuk kelajak sari. – Toshkent: O'zbekiston, 1998. – B. 89–90



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concept acquires a distinctive meaning: the region is bounded by the Karakum and Kyzylkum deserts, dominated by an arid climate, and characterized by closed river basins. These geographic and climatic features render ecological security an inseparable component of both national and regional security².

Historically, the peoples of Central Asia developed a distinctive traditional system of knowledge for managing water resources and maintaining agro-ecological balance, embodied in the institution of the *mirob* (water master). However, this tradition was rejected under the Soviet regime, which replaced it with centralized irrigation systems that consumed vast amounts of water. As a result, severe disruptions to ecological systems began to unfold across the region—disruptions that continue to this day.

The agrarian policy of Soviet rule in Central Asia was closely tied to the large-scale cotton monoculture program implemented between the 1930s and 1980s. To harness the waters of the Amu Darya and Syr Darya, massive canals were constructed — including the Karakum Canal (1954), the Southern Mirzachol Canal, and the Amu-Bukhara Canal. While these projects proved economically effective, they left devastating ecological consequences³. Between 1960 and 1990, the area of land brought under irrigation expanded nearly 3.5 times, resulting in an unprecedented increase in water consumption⁴. The widespread use of chemical fertilizers and pesticides (such as DDT and defoliants) for cotton cultivation contaminated soils and groundwater. Scientific studies have shown that in several regions of Uzbekistan, residual pesticide concentrations in soils were 10–15 times higher than international standards. This caused severe damage not only to ecosystems but also to the health of local populations.

The Aral Sea disaster is classified as one of the largest man-made ecological catastrophes in modern history⁵. In the 1960s, the Aral Sea covered an area of 68,000 km² with a volume of 1,090 km³. By 1990, its surface area had shrunk to 40,000 km², and by the 2000s it had split into two separate basins — the Small Aral and the Large Aral. This process was driven by the diversion of water from the Amu Darya and Syr Darya rivers, which exceeded their natural flow capacity⁶.

The collapse of the Aral Sea triggered a chain reaction of ecological crises. In place of the dried seabed, a new desert known as *Aralkum* emerged, whose toxic salts, pesticide residues, and dust are carried by winds up to 500 kilometers. This phenomenon has led to a sharp decline in biodiversity: the fishing industry has completely disappeared, and more than 50 fish species have been lost. Moreover, the incidence of respiratory and cardiovascular diseases among the population of the Aral Sea region is three to four times higher than the Central Asian average.

² Toshmatov N.A. Markaziy Osiyo ekologik xavfsizligi muammolari: tarixiy tahlil. – Toshkent: Fan, 2015. – B. 34–

³ Dushamov Jamshidbek Olimboy o'g'li. Climate Change and Central Asian Geopolitics // Arabian Journal of Science. International Multidisciplinary Online Journal. – 2026. – Vol. 3, No. 6. – P. 35

⁴ Glantz Michael H. Climate Change and Water Resources in Central Asia. – Dordrecht: Springer, 2010. – P. 91

⁵ Abdullayev I., Atabaev I. Orol dengizi muammosi va uning ijtimoiy-ekologik oqibatlar. – Toshkent: SAREC, 2008. – B. 15

⁶ Small I., van der Meer J., Upshur R.E.G. Acting on an environmental health disaster: The case of the Aral Sea // Environmental Health Perspectives. – 2001. – Vol. 109, No. 6. – P. 547

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The five Central Asian states — Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan — are compelled to jointly regulate the distribution of water in the two principal river basins of the Amu Darya and Syr Darya. Yet interstate agreements on water allocation remain unresolved⁷. The Alma-Ata Agreement of 1992 envisaged the distribution of water shares based on quotas established during the Soviet era; however, in practice its implementation has often been hindered by political interests⁸.

Kyrgyzstan and Tajikistan, situated upstream, have sought to manage river flows for energy purposes through the construction of the Toktogul and Rogun hydroelectric stations. This has resulted in water shortages during the summer irrigation season and heightened flood risks in winter for downstream countries such as Uzbekistan and Turkmenistan.

According to IPCC assessments, Central Asia ranks among the regions most vulnerable to climate change. Over the past seventy years, the average annual temperature in the region has risen by 1.5–2°C, a rate approximately 1.5 times faster than the global average⁹. The retreat of glaciers represents a particularly acute challenge: since the 1960s, the volume of glaciers in the Tian Shan and Pamir ranges has declined by 25–30 percent, and this process continues to accelerate.

Climate change is also reshaping the seasonal distribution of water resources. Winter precipitation has decreased, while summer droughts have become increasingly frequent. As Glantz observes, this situation severely undermines irrigated agriculture, threatening to reduce crop yields by 20–30 percent. In Uzbekistan, such transformations are already evident: the summer flows of the Zarafshan and Chirchik rivers have significantly diminished, intensifying water scarcity and weakening agricultural productivity.

The problem of desertification holds critical significance for Central Asia. More than 80 percent of the region's territory lies within arid or semi-arid zones. In Uzbekistan, over 50 percent of irrigated lands are affected by salinization, which drastically reduces agricultural productivity¹⁰. Soil degradation generates not only economic but also demographic challenges: the displacement of populations from lands that have lost fertility — a process of ecological migration — has emerged as a new social issue¹¹.

From the perspective of biodiversity, the region has suffered substantial losses. Much of the unique flora and fauna of the Aral Sea basin has disappeared. According to the research of Bekturov and Yusupova, in the past forty years more than 30 plant

⁷ Qodirov A.Q. Amudaryo va Sirdaryo havzalarida suv resurslaridan foydalanishning ekologik muammolari // O'zbekiston geografiya jamiyati axboroti. – 2019. – T. 57. – B. 120

⁸ Sievers Eric V. The Post-Soviet Decline of the Aral Sea: Inefficiency of Coalition, or Drainage of an Unproductive Elite? // Central Asian Survey. – 2002. – Vol. 21, No. 4. – P. 471

⁹ IPCC. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. – Cambridge: Cambridge University Press, 2021. – P. 1120

¹⁰ Rasulova M.N. Markaziy Osiyoda cho'llanish jarayonlari va ularning demografik oqibatlari // Geografiya va tabiiy resurslar. – 2017. – № 3. – B. 78

¹¹ Nishanov B.T. Ekologik muammolarning migratsion jarayonlarga ta'siri: O'zbekiston misoli // O'zbekiston ijtimoii fanlar jurnali. – 2020. – № 2. – B. 55

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species and over 20 vertebrate species in Uzbekistan have come under threat of extinction¹². This situation has disrupted ecological chains and undermined agro-ecological stability in agriculture.

The interconnection between ecological degradation and demographic dynamics is particularly evident in the case of Central Asia. In the Aral Sea region, population outmigration began in the 1980s and has continued to the present day. According to Nishanov's research, more than 200,000 people left Karakalpakstan between 1989 and 2010 due to ecological causes. This not only altered the demographic composition of the region but also weakened social infrastructure and economic activity, thereby reinforcing the chronic nature of ecological problems.

Official statistics indicate that currently between 5 and 8 million people in Central Asia are at risk of becoming "ecological migrants." The UNDP report projects that by 2050, climate change could force an additional 1–2 million people in the region to abandon their homes¹³. These figures highlight that ecological security must be assessed not only as an environmental issue but also as a challenge to social and political stability.

Since gaining independence, Uzbekistan has taken several important steps in the field of environmental policy. In 1992, the Law of the Republic of Uzbekistan "*On Environmental Protection*" was adopted. Later, the "*Green Economy*" concept (2013–2030) and the Presidential Decree of 2019 further strengthened the institutional foundations of environmental policy¹⁴.

On the international stage, Uzbekistan has been actively engaged in initiatives under the International Fund for Saving the Aral Sea (IFAS). Established in 1993, IFAS has implemented programs aimed at improving water supply for millions of people and addressing ecological problems in the Aral Sea region¹⁵. Moreover, Uzbekistan succeeded in bringing the Aral issue to the agenda of the UN General Assembly and proposed the creation of a special UN program dedicated to the Aral Sea crisis¹⁶.

Under the leadership of President Shavkat Mirziyoyev, Uzbekistan has elevated its ecological diplomacy to a new level. In his 2021 address to the UN General Assembly, Mirziyoyev proposed the establishment of a UN Special Program for the Aral Sea Basin. This initiative was positively received by the international community and marked a significant step in placing the Aral issue on the global ecological agenda.

In Central Asia, ecological security cannot be achieved through the efforts of a single state; it requires regional cooperation. According to the research of Hamidov and

¹² Bekmurodov A.Sh., Yusupova D.I. O'zbekistonda biologik xilma-xillikni saqlash va ekotizimlar barqarorligi muammolari // Ekologiya va atrof-muhit jurnali. – 2022. – № 1. – B. 10

¹³ UNDP. Human Development in Central Asia: Addressing Water Scarcity and Climate Vulnerability. – New York: UNDP, 2020. – P. 33

¹⁴ O'zbekiston Respublikasi Prezidentining 2019-yil 30-oktabrdagi PF-5863-son Farmoni "O'zbekiston Respublikasida ekologik siyosatni yanada takomillashtirish chora-tadbirlari to'g'risida". – Toshkent, 2019.

¹⁵ IFAS. Annual Report 2022: Water and Environment in the Aral Sea Basin. – Ashgabat: IFAS Secretariat, 2022. – P. 8

¹⁶ Mirziyoyev Sh.M. BMT Bosh Assambleyasining 76-sessiyasida so'zlagan nutqi. – Nyu-York, 2021-yil 22-sentabr. – URL: <https://president.uz>



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Kasymov, the water management institutions created during the Soviet era have become largely ineffective under conditions of independence, necessitating the establishment of new integrative mechanisms¹⁷. The World Bank report emphasizes that adapting Central Asian irrigated agriculture to climate change will require investments of 18–20 billion USD by 2030¹⁸.

Promising directions include:

1. Broad introduction of water-saving technologies such as drip irrigation and smart-irrigation systems.
2. Strengthening the legal framework for transboundary river management.
3. Implementing biotechnical measures aimed at partial restoration of the Aral Sea basin.
4. Electrification of irrigation pumps based on renewable energy sources.
5. Enhancing public ecological literacy and awareness.

According to UNEP, comprehensive implementation of these measures could prevent degradation on up to 30 percent of Central Asian lands by 2050.

3. Conclusion

The ecological crisis in Central Asia must be understood as the outcome of a complex interplay of historical, geopolitical, and socio-economic factors. The chain of problems that began with Soviet-era irrigation and agrarian policies now manifests in the form of climate change, desertification, water scarcity, biodiversity loss, and ecological migration. The Aral Sea disaster, as the most dramatic link in this chain, delivered a sobering lesson to humanity about ecological responsibility.

During the years of independence — particularly under the leadership of President Shavkat Mirziyoyev — Uzbekistan has achieved significant progress in the sphere of ecological security: elevating the Aral issue to the international agenda, developing the *Green Economy* concept, and strengthening regional cooperation. Yet, fully addressing these challenges requires the consolidation of interstate political will, acceleration of technological modernization, and harmonization of socio-economic reforms with environmental policy.

Scientific analysis demonstrates that ensuring ecological security in Central Asia depends on broad transboundary cooperation, intensified scientific and practical research, and mobilization of international financial resources. The solidarity of regional states in confronting ecological challenges, together with their political determination to overcome them, represents the only path toward leaving a worthy future for humanity.

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¹⁸ World Bank. Central Asia: Adapting to Climate Change in Irrigated Agriculture. – Washington D.C.: World Bank, 2019. – P. 15



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THE IMPORTANCE OF INFORMATION TECHNOLOGIES IN TEACHING ENGLISH

Asadova Gulrux Islomovna

Buxoro shahar 1- son texnikumi ingliz tili fani o'qituvchisi

Annotation: The article describes the importance of using Information Technologies in teaching English. It deals with some problems in the process of teaching EFL for students. Nowadays the importance of incorporating Information Technologies in English language education has often been emphasized, especially by foreign language pedagogy scholars.

Key words: english language, communication, information technology, skill, method, computer, listening material, e-book

Currently, learning english languages have become a widely spread phenomenon in the globalized world. We are living in such times when the rapid development of information and communication technologies generates a number of radical change is in our lives, including in the educational process. The position of the English language in the world as the leading means of international communication is associated primarily with the rapid development of high technologies, economics, and technologies. This strengthens the motivation of students who want to learn English as foreign language of intergovernmental communication and scientific research.

The 21st century is the age of globalization and information technology as Harry Samuels argues, "Much more recent developments in social media and information technology are taking english-language education in new directions" [18]. English is one of the important mediums of communication in the world, so it is important to learn the language. As a result, English language teaching has been one of the important subjects in education. In fact, there are more non-native than native speakers of the language. There is also the diversity of context in terms of learner's age, nationality, and learning background that has become an important feature of English language teaching today. The need to teach in general and teach the English language effectively, in particular, is the challenge before all the teachers in Uzbekistan.

Technology is an effective tool for learners. Learners must use technology as a significant part of their learning process. Teachers should model the use of technology to support the curriculum so that learners can increase the true use of technology in learning their language skills. As English has gained its popularity so it has become a need for qualified teachers to instruct students in language learning in the easiest way possible. It is true that there are teachers who use advanced technology for interactive teaching, but the majority of teachers are still teaching in the traditional manner. None of these traditional methods of teaching are bad or unuseful for students. As technologies are changing English learning and teaching (ELT) needs to be upgraded to the next level. In fact, to date, they are proving to be useful also. However, there are many more opportunities for students to gain confidence in practice and extend themselves. It is like how teachers use



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technology to perform familiar activities more effectively and how this usage can re-shape these activities. It supports classroom teaching by completing assignments on the computer rather than a normal pencil and paper. This enhances the use of technology as well as it allows the students to interact with new information technologies. According to Bransford, Brown, and Cocking, the application of computer technology enables teachers and learners to make local and global societies that connect them with the people and expand opportunities for their learning. They continued that the positive effect of computer technology does not come automatically; it depends on how teachers use it in their language classrooms. According to Susikaran, basic changes have come in classes besides the teaching methods because chalk and talk teaching method is not sufficient to effectively teach English.

Raihan and Lock state that with a well-planned classroom setting, learners learn how to learn efficiently. The technology-enhanced teaching environment is more effective than a lecture-based class. Teachers should find methods of applying technology as a useful learning instrument for their learners although they have not learned technology and are not able to use it as a computer expert. According to Susikaran, basic changes have come in classes besides the teaching methods because chalk and talk teaching method is not sufficient to effectively teach English. Raihan and Lock state that with a well planned classroom setting, learners learn how to learn efficiently. The technology-enhanced teaching environment is more effective than a lecture-based class. Teachers should find methods of applying technology as a useful learning instrument for their learners although they have not learned technology and are not able to use it as a computer expert. The application of technology has considerably changed English teaching methods. It provides so many alternatives as making teaching interesting and more productive in terms of advancement. In traditional classrooms, teachers stand in front of learners and give lecture, explanation, and instruction through using blackboard or whiteboard. This method must be changed concerning the development of technology. The usage of multimedia texts in the classroom assists learners to become familiar with vocabulary and language structures. The application of multimedia also makes use of print texts, film, and internet to enhance learners' linguistic knowledge.

English language skills learning has been anytime possible through ICTs. The students can find language learning materials such as e-books, journals, articles for enhancing their reading and writing skills; and videos, conversations, and discussions for improving listening and speaking skills. Likewise, the students can find different reference materials such as dictionaries, and grammar books; and language skills related exercises, apps, or online/offline programs to practice English language skills. In the discussion, the students in college A shared their experiences that ICTs have made English language learning easier and faster. They could download the English language learning materials such as videos, conversations, books, articles, and many more English language learning apps and programs. ICTs help them exchange their ideas and information; and discuss their queries with their teachers and friends anytime they like. The class teacher in the college Bagreed that ICTs could be used to facilitate the student stop develop their English

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language skills. The advantage was that ICTs helped them to provide several types of learning materials that could increase the amount of exposure to English. Similarly, ICTs were useful to make updates of their current knowledge, information, and to understand recent pedagogical trends. The teacher from college opined: The advantages of ICTs are that they provide the students with ample exposure to the English language to promote their language skills. The students can use several browsers for searching and downloading several language skills improving exercises and programs. ICTs help me to motivate the students in the class and make their learning long-lasting as they can engage both visual and auditory sensory organs of the students through texts, images, sounds, and motions. Similarly, in the discussion, the students in college B expressed that ICT-based education and ICTs were quite beneficial to them in learning English language skills. The tools help them search and collect English language skills learning materials and practice all types of language skills. The learning resources such as English language dictionaries, English grammar related reference materials, language learning apps which are available through ICTs were very useful them to enhance English language skills. Moreover, the tools such as laptops, smart phones, projectors, email, Skype, Facebook groups, and discussion forums help them share their resources, ideas, and information in easier and less effortful ways.

The implementation of ICT will lead to variety in English content, contexts and pedagogical methods in teaching environment. ICT makes English language environment interactive, flexible and innovative. The application of computer technologies in language instruction provides a student-centered learning environment. It enables course administrators and teachers to vary lesson presentation styles to motivate students of varying interests, provides learning opportunities outside the classroom, and is perceived to cater more for individual differences. Integrating technology into language instruction reduces teacher-centered understanding and students' language learning anxiety, but encourages them to be risk takers to practice target language as they are digital natives. Jayanthi and Kumar [9, p.34-38] explain the positive impacts of ICT on ELT under the basic headings such as: availability of materials, students' attitudes, learner autonomy, authenticity, helping teachers, student-centered, and self-assessment. The availability of large body of authentic materials such as images, animation, audio and video clips facilitate presenting and practicing language. As for students' attitudes, ICTs increase motivation. The students feel highly motivated to learn a language as they displayed positive attitudes towards language learning as they use computer and learn in stress-free learning environment. In addition, ICT fosters learner autonomy as ICT tools provide learners to take responsibilities for their own learning. Students are free to choose the material convenient for their learning styles.

Furthermore, ICT provides authentic situations and real life learning environment. As ICTs offer different types of facilities and availability of teaching materials, EFL teachers only suggest and design these tools as complementary teaching materials. Contrary to traditional learning environment, ICT supports student-centred learning together with teacher-student interaction.

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As for assessment, with the ICTs both receptive and productive skills are effectively assessed. The teacher may decide and design relevant materials to test students' achievement in all skills. Additionally, the following impacts seemed to be the most obvious ones when using ICT to support foreign language teaching:

-The possibility to adapt easily the teaching materials according to circumstances, learner's needs and response;

-ICT allows to react upon and enables the use of recent/daily news, it offers access to authentic materials on the web;

-Possibility to combine/use alternately (basic) skills (text and images, audio and video clip);

-Lectures become more interesting and less ordinary which boosts learners' engagement;

-ICT enables to focus on one specific aspect of the Lesson.

The advantages of ICT usage in english language teaching could be listed as:

1. Capacity to control presentation. This capacity marks the difference between computers and books. Books have a fixed presentation, unlike computers, which can combine visual with listening materials, text with graphics and pictures.

2. Novelty and creativity. A teacher may use different materials for each lesson, not like in teaching with textbooks, where all classes presenting a certain topic are the same.

3. Feedback. Computers provide a fast feedback to students' answers through error correction. It not only spots the mistake but also corrects it, sometimes even giving the appropriate advice.

4. Adaptability. Computer programmes can be adapted by teachers to suit their students' needs and level of language knowledge .

There is significant evidence of the benefits and advantages that the use of ICT can have on learners. The effective use of ICT impacts on learners and various aspects of the learning process can be summarized as follows: ICT increases learners' motivation and thus enhances personal commitment and engagement; ICT improves independent learning; Learners' collaboration and communication are more important; Learners' attainment and outcomes are improved . On the other hand, the integration of ICT in classrooms can also bring certain disadvantages.

Teachers may have difficulty in relation to the integration and implementation of technological tools into course syllabus and curriculum. There are necessities to bear in mind before to use ICTs in EFL classrooms. Therefore, Livingstone asserts that ICT "is not suitable for all learners in all situations and for all purposes, and may require some considerable learner training for effective use". The problems in classroom management, the lack of highly experienced teachers, choosing the best technological tool matching with course content, finding reliable and acceptable activities for students' learning styles, the costs of new technological tools, and devices, insufficient physical capacity of classrooms are only certain remarkable issues to be taken into consideration before employment of ICTs in language classrooms.



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Preston and Cox state the drawbacks of using ICTs in classrooms as follows: difficulties in using software/hardware, need more technical support, not enough time to use ICT, too expensive to use regularly, insufficient access to the resources, restrictions the content of the lessons, counter-productive due to insufficient technical resources [5]. It is vital to effectively integrate technology into the classroom that an on-site technical assistant be recruited to assist teachers when needed . It seems reasonable to assume that education teaching and learning should satisfy the needs and interests that people have as a result of new work and technological demands. However, there are aspects of such discourse that need to be carefully considered. In this regard, Van Dijk argues for the relevance of studying how power, domination and social order are imposed, reproduced, and controlled through discourse. He points out that education tends to enact institutional and professional practices associated with power abuse and discursive reproduction; in particular, such abuse and reproduction are present when particular topics, actions and rules are standardized and formalized according to the interests and needs of a specific set of actors. Furthermore, Rogers claims that educators need to analyze discourse critically to be able to describe, interpret, and explain the current relationship among the economy, national policies, and educational practices.

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BLOOD BIOCHEMISTRY AND HEME SYNTHESIS: MOLECULAR MECHANISMS, BIOCHEMICAL REGULATION, AND CLINICAL SIGNIFICANCE

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Abstract: Blood biochemistry plays a fundamental role in understanding physiological and pathological processes within the human body. Among the essential biochemical pathways, heme synthesis represents a critical metabolic process necessary for oxygen transport, cellular respiration, detoxification, and enzymatic reactions. Heme serves as a prosthetic group in hemoglobin, myoglobin, cytochromes, catalase, and numerous oxidoreductase enzymes. Disturbances in heme biosynthesis lead to various hematological and metabolic disorders, including sideroblastic anemia and porphyrias. This review discusses the biochemical principles of blood composition, molecular mechanisms of heme biosynthesis, regulatory pathways, associated diseases, laboratory diagnostic markers, and recent advances in clinical biochemistry. The article highlights the importance of understanding heme metabolism for modern laboratory diagnostics and personalized medicine.

Keywords: Blood biochemistry, heme synthesis, porphyrins, hemoglobin, iron metabolism, porphyria, erythropoiesis, ferrochelatase, aminolevulinic acid.

Introduction

Blood is a specialized connective tissue responsible for the transportation of gases, nutrients, hormones, metabolic products, and immune components throughout the body. The biochemical composition of blood reflects physiological homeostasis and serves as a valuable source of diagnostic information.[1,2,3,4,5,6]

Among numerous biochemical pathways occurring in blood cells, heme biosynthesis occupies a central position. Heme is an iron-containing tetrapyrrole molecule required for oxygen transport and cellular energy production. Approximately 80–85% of heme synthesis occurs in erythroid precursor cells of the bone marrow, while the remaining synthesis takes place primarily in hepatocytes where heme supports cytochrome P450-dependent metabolism. The biosynthesis of heme involves eight enzyme-catalyzed reactions distributed between the mitochondria and cytoplasm. Defects in this pathway result in severe metabolic and hematological disorders.[7,8,9,10,11,12]

Biochemical Composition of Blood

Blood consists of plasma and cellular elements.

Plasma Components

Plasma accounts for approximately 55% of total blood volume and contains:

Water (90–92%)

Proteins (albumin, globulins, fibrinogen)

Electrolytes





Hormones

Lipids

Vitamins

Metabolic products

Major plasma proteins perform transport, buffering, coagulation, and immune functions.

Cellular Components

The formed elements include:

Erythrocytes (red blood cells)

Leukocytes (white blood cells)

Platelets (thrombocytes)

Erythrocytes contain hemoglobin, the primary oxygen-carrying protein whose function depends directly on heme biosynthesis.[13,14,15,16,17]

Structure and Biological Functions of Heme

Heme is chemically defined as ferrous (Fe^{2+}) protoporphyrin IX. The molecule consists of a porphyrin ring structure coordinated with a central iron atom. Heme functions as an essential prosthetic group for numerous proteins involved in oxygen transport, electron transfer, oxidative phosphorylation, and detoxification pathways.

Major heme-containing proteins include:

Hemoglobin

Myoglobin

Cytochromes

Catalase

Peroxidases

Cytochrome P450 enzymes

Nitric oxide synthase

The unique chemical structure of heme enables reversible oxygen binding and electron transfer reactions essential for life.

Heme Biosynthetic Pathway

Heme biosynthesis occurs through an eight-step enzymatic pathway involving both mitochondrial and cytosolic compartments.

Step 1: Formation of δ -Aminolevulinic Acid (ALA)

The first and rate-limiting reaction occurs within mitochondria:

Glycine + Succinyl-CoA $\rightarrow$ δ -Aminolevulinic Acid (ALA)

The reaction is catalyzed by ALA synthase (ALAS) and requires pyridoxal phosphate (vitamin B6) as a cofactor. This step serves as the principal regulatory point of heme synthesis.[18,19,20,21,22]

Step 2: Formation of Porphobilinogen

Two molecules of ALA condense to form porphobilinogen (PBG) under the action of ALA dehydratase.

Step 3: Formation of Hydroxymethylbilane

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Four molecules of porphobilinogen are polymerized by porphobilinogen deaminase to produce hydroxymethylbilane.

Step 4: Formation of Uroporphyrinogen III

Hydroxymethylbilane undergoes cyclization to form uroporphyrinogen III.

Step 5: Formation of Coproporphyrinogen III

Decarboxylation reactions convert uroporphyrinogen III into coproporphyrinogen III.

Step 6: Formation of Protoporphyrinogen IX

Coproporphyrinogen III is transported back into mitochondria where further enzymatic modification produces protoporphyrinogen IX.

Step 7: Formation of Protoporphyrin IX

Oxidation of protoporphyrinogen IX results in protoporphyrin IX.

Step 8: Formation of Heme

The final reaction is catalyzed by ferrochelatase, which inserts ferrous iron (Fe^{2+}) into protoporphyrin IX to generate heme.[23,24,25,26]

Regulation of Heme Synthesis

Heme biosynthesis is tightly regulated to maintain cellular homeostasis.

Hepatic Regulation

In hepatocytes, intracellular heme acts through negative feedback mechanisms to inhibit ALAS1 expression and activity. This regulation prevents excessive accumulation of free heme, which may exert cytotoxic effects.

Erythroid Regulation

In erythroid cells, ALAS2 expression depends primarily on iron availability. Iron-responsive elements regulate translation of ALAS2 mRNA, coordinating hemoglobin synthesis with iron supply.[27,28,29,30]

Hormonal Regulation

Several hormones influence heme biosynthesis:

Erythropoietin

Glucocorticoids

Thyroid hormones

Growth factors

These regulators increase heme production during erythropoiesis.

Relationship Between Iron Metabolism and Heme Synthesis

Iron availability directly influences heme production. Approximately 70% of total body iron is incorporated into hemoglobin.

Iron transport involves:

Transferrin

Transferrin receptors

Ferritin

Ferroportin



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Bone marrow erythroblasts acquire iron through transferrin-mediated endocytosis. The iron is subsequently delivered to mitochondria for incorporation into protoporphyrin IX during heme synthesis.

Iron deficiency results in reduced hemoglobin production and microcytic hypochromic anemia.

Clinical Disorders Associated with Defective Heme Synthesis

Porphyrias

Porphyrias are inherited or acquired disorders resulting from deficiencies in enzymes of the heme biosynthetic pathway.

Major forms include:

Acute intermittent porphyria

Variegate porphyria

Hereditary coproporphyria

Porphyria cutanea tarda

Erythropoietic protoporphyria

Each disorder is characterized by accumulation of specific pathway intermediates causing neurological, dermatological, or hematological manifestations.[31,322,33]

Sideroblastic Anemia

Sideroblastic anemia results from impaired incorporation of iron into heme.

Characteristic findings include:

Ring sideroblasts

Ineffective erythropoiesis

Increased iron stores

Reduced hemoglobin synthesis

Mutations affecting ALAS2 represent a common hereditary cause.

Biochemical Laboratory Evaluation of Heme Metabolism

Modern clinical laboratories assess heme metabolism using various biochemical markers.

Hematological Tests

Hemoglobin concentration

Hematocrit

Red blood cell count

Reticulocyte count

Iron Studies

Serum iron

Ferritin

Total iron-binding capacity

Transferrin saturation

Porphyrin Analysis

Measurement of:

ALA

Porphobilinogen





Urinary porphyrins

Plasma porphyrins

These investigations facilitate diagnosis of porphyrias and disorders of erythropoiesis.

Modern Advances in Heme Research

Recent investigations have revealed that heme functions not only as a prosthetic group but also as a signaling molecule regulating:

Gene expression

Circadian rhythms

MicroRNA processing

Cellular differentiation

Oxidative stress responses

The concept of intracellular heme trafficking has emerged as a major area of biomedical research. Specialized transport proteins regulate heme movement between cellular compartments, ensuring adequate supply while preventing toxicity.

Novel therapeutic strategies targeting heme metabolism are being explored for:

Porphyrias

Anemia

Cancer

Mitochondrial disorders

Neurodegenerative diseases

Clinical Significance in Blood Biochemistry

Assessment of heme metabolism provides valuable information regarding:

Iron status

Bone marrow activity

Liver function

Mitochondrial metabolism

Erythropoietic capacity

Biochemical markers of heme synthesis are increasingly integrated into precision medicine approaches, allowing earlier diagnosis and individualized treatment planning.[34,35,36]

Conclusion

Heme synthesis represents one of the most fundamental biochemical pathways in human physiology. Through its involvement in oxygen transport, cellular respiration, detoxification, and signaling pathways, heme contributes to numerous essential biological functions. Blood biochemistry provides powerful diagnostic tools for evaluating heme metabolism and detecting associated disorders. Advances in molecular biology, metabolomics, and laboratory diagnostics continue to improve our understanding of heme biosynthesis and its clinical implications. Future research focusing on heme regulation and transport mechanisms may provide novel therapeutic opportunities for a wide range of hematological and metabolic diseases.

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BIOLOGICAL FUNCTIONS OF CARBOHYDRATES: GLUCOSE AND GLYCOGEN METABOLISM IN HUMAN PHYSIOLOGY

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Abstract: Carbohydrates are among the most important biomolecules in living organisms, serving as primary sources of energy, structural components, and regulators of numerous physiological processes. Glucose represents the central molecule of carbohydrate metabolism and functions as the principal energy substrate for most tissues, particularly the brain and erythrocytes. Glycogen serves as the major storage form of glucose in animals and plays a critical role in maintaining blood glucose homeostasis. The metabolism of glucose and glycogen involves a complex network of biochemical pathways regulated by hormonal, enzymatic, and genetic mechanisms. Disturbances in carbohydrate metabolism contribute to the pathogenesis of numerous diseases, including diabetes mellitus, glycogen storage diseases, obesity, metabolic syndrome, and cardiovascular disorders. This review summarizes the biological functions of carbohydrates, the molecular mechanisms underlying glucose and glycogen metabolism, regulatory pathways involved in carbohydrate homeostasis, and the clinical significance of metabolic disturbances. Recent advances in molecular biology and metabolic research have improved understanding of carbohydrate metabolism and opened new opportunities for diagnosis and treatment of metabolic diseases.

Keywords: carbohydrates, glucose metabolism, glycogen metabolism, glycolysis, glycogenesis, glycogenolysis, gluconeogenesis, metabolic regulation.

Introduction

Carbohydrates constitute one of the three major classes of macronutrients essential for life. They are synthesized primarily through photosynthesis and represent the most abundant organic compounds in nature. In humans, carbohydrates account for a significant proportion of daily energy intake and serve as critical substrates for cellular metabolism.[1,2,3,4,5,6]

The importance of carbohydrates extends beyond energy production. They participate in cell signaling, molecular recognition, immune responses, and structural organization of tissues. Among all carbohydrates, glucose occupies a central position in metabolism because it serves as the primary fuel for numerous organs and tissues.[7,8,9,10]

The regulation of glucose concentration in blood is vital for maintaining physiological homeostasis. Excess glucose is stored in the form of glycogen, while insufficient glucose availability stimulates glycogen breakdown and alternative metabolic pathways. Understanding the mechanisms governing glucose and glycogen metabolism is therefore essential for understanding both normal physiology and disease development.[11,12,13,14]



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Classification and Biological Functions of Carbohydrates

Carbohydrates are classified according to their chemical structure and complexity.

Monosaccharides

These are the simplest carbohydrate units.

Examples include:

- Glucose
- Fructose
- Galactose

Disaccharides

Disaccharides consist of two monosaccharide molecules.

Examples include:

- Sucrose
- Lactose
- Maltose

Polysaccharides

Polysaccharides are complex carbohydrates composed of multiple monosaccharide units.

Examples include:

- Glycogen
- Starch
- Cellulose

Biological Functions of Carbohydrates

Carbohydrates perform multiple physiological functions.

Energy Function

The most important role of carbohydrates is energy production.

Oxidation of one gram of carbohydrate produces approximately 4 kilocalories of energy.[15,16,17,18,19]

Glucose serves as the principal energy substrate for:

- Brain tissue
- Erythrocytes
- Skeletal muscle
- Cardiac muscle
- Renal medulla

Under normal physiological conditions, glucose accounts for a substantial portion of cellular ATP production.

Storage Function

Excess glucose is stored as glycogen.

Major glycogen reserves are located in:

- Liver
- Skeletal muscle

This storage mechanism ensures a continuous energy supply during fasting and physical activity.





Structural Function

Carbohydrates are important structural components of cells and tissues.

Examples include:

- Glycoproteins
- Glycolipids
- Proteoglycans
- Extracellular matrix components

These molecules contribute to membrane stability and cell communication.

Protective Function

Mucopolysaccharides and glycoproteins protect epithelial surfaces from mechanical and chemical injury.

Protective carbohydrate-containing structures are found in:

- Gastrointestinal tract
- Respiratory system
- Urogenital tract

Cell Recognition and Signaling

Cell-surface carbohydrates participate in:

- Immune recognition
- Cell adhesion
- Signal transduction
- Blood group antigen determination

These functions are essential for normal physiological communication between cells.[20,21,22,23,24]

Glucose Metabolism

Glucose metabolism encompasses multiple interconnected biochemical pathways.

The major pathways include:

1. Glycolysis
2. Glycogenesis
3. Glycogenolysis
4. Gluconeogenesis
5. Pentose phosphate pathway

Together these pathways maintain energy balance and metabolic homeostasis.

Glycolysis

Glycolysis is the metabolic pathway through which glucose is converted into pyruvate.

The overall reaction is:



Glycolysis occurs in the cytoplasm of all cells and does not require oxygen.

Major functions include:

- ATP production
- Generation of metabolic intermediates
- Maintenance of erythrocyte energy metabolism

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Key regulatory enzymes include:

- Hexokinase
- Phosphofructokinase-1
- Pyruvate kinase

The pathway is tightly regulated according to cellular energy requirements.

Aerobic Oxidation of Glucose

Under aerobic conditions, pyruvate enters mitochondria and is converted into acetyl-CoA.

Acetyl-CoA enters the citric acid cycle, resulting in:

- Carbon dioxide production
- Electron transport chain activation
- Large-scale ATP synthesis

Complete oxidation of one glucose molecule generates approximately 30–32 ATP molecules.[25,26,27,28]

This process represents the most efficient mechanism of cellular energy production.

Pentose Phosphate Pathway

The pentose phosphate pathway serves several essential functions.

It generates:

- NADPH
- Ribose-5-phosphate

NADPH is required for:

- Fatty acid synthesis
- Cholesterol synthesis
- Antioxidant defense

Ribose-5-phosphate is necessary for nucleotide synthesis.

The pathway is especially important in erythrocytes, liver, and adipose tissue.

Glycogen Metabolism

Glycogen is the principal storage polysaccharide in animals.

Its highly branched structure enables rapid synthesis and degradation.

Approximately:

- 100–120 g glycogen is stored in the liver
- 300–500 g glycogen is stored in skeletal muscles

These reserves provide a readily available source of glucose during increased metabolic demand.[29,30,31,32]

Glycogenesis

Glycogenesis refers to glycogen synthesis.

The process occurs primarily after meals when glucose availability is abundant.

Major steps include:

1. Glucose phosphorylation
2. Formation of glucose-1-phosphate
3. Synthesis of UDP-glucose
4. Glycogen chain elongation



The key enzyme is:

Glycogen Synthase

Insulin stimulates glycogenesis by activating glycogen synthase and promoting glucose uptake into tissues.[33,34]

Glycogenolysis

Glycogenolysis is the breakdown of glycogen into glucose-containing products.

This pathway becomes active during:

- Fasting
- Exercise
- Stress
- Hypoglycemia

The key enzyme is:

Glycogen Phosphorylase

In the liver, glycogenolysis contributes directly to blood glucose maintenance.

In skeletal muscle, glycogen breakdown primarily supports local energy production.

Hormonal Regulation of Glucose and Glycogen Metabolism

Carbohydrate metabolism is controlled by several hormones.

Insulin

Insulin promotes:

- Glucose uptake
- Glycogenesis
- Glycolysis
- Lipogenesis

It lowers blood glucose concentration.

Glucagon

Glucagon stimulates:

- Glycogenolysis
- Gluconeogenesis

It increases blood glucose levels during fasting.

Epinephrine

Epinephrine activates glycogen breakdown during stress and physical activity.

Cortisol

Cortisol enhances gluconeogenesis and supports adaptation to prolonged stress.

The coordinated actions of these hormones maintain glucose homeostasis.

Gluconeogenesis

Gluconeogenesis is the synthesis of glucose from non-carbohydrate precursors.

Major substrates include:

- Lactate
- Glycerol
- Amino acids

The process occurs mainly in:

- Liver



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- Kidney cortex

Gluconeogenesis is essential during prolonged fasting and starvation.

Disorders of Glucose and Glycogen Metabolism

Abnormal carbohydrate metabolism contributes to numerous diseases.

Diabetes Mellitus

Characterized by:

- Hyperglycemia
- Insulin deficiency or resistance
- Altered glucose utilization

Long-term complications affect:

- Blood vessels
- Kidneys
- Eyes
- Nervous system

Glycogen Storage Diseases

These inherited disorders result from deficiencies of enzymes involved in glycogen metabolism.

Examples include:

- Von Gierke disease
- Pompe disease
- Cori disease
- McArdle disease

Clinical manifestations vary depending on the affected enzyme.

Hypoglycemia

Low blood glucose levels may result from:

- Excess insulin
- Liver disease
- Endocrine disorders
- Glycogen storage diseases

Severe hypoglycemia can impair brain function and become life-threatening.

Recent Advances in Carbohydrate Metabolism Research

Recent scientific developments have improved understanding of metabolic regulation.

Important advances include:

- Continuous glucose monitoring systems
- Metabolomics technologies
- Gene therapy approaches
- Precision medicine strategies
- Artificial intelligence-assisted metabolic analysis

These innovations are transforming the diagnosis and treatment of metabolic diseases.[35,36]

Conclusion



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Carbohydrates perform diverse biological functions that extend beyond energy production. Glucose serves as the central metabolic fuel, while glycogen provides an efficient storage mechanism that maintains energy homeostasis during periods of fluctuating nutrient availability. The pathways of glycolysis, glycogenesis, glycogenolysis, gluconeogenesis, and the pentose phosphate pathway are intricately regulated by enzymes and hormones to ensure stable blood glucose concentrations. Disturbances in these processes contribute to the development of major metabolic disorders, including diabetes mellitus and glycogen storage diseases. Continued research into carbohydrate metabolism is essential for improving prevention, diagnosis, and treatment of metabolic diseases in modern medicine.

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DISORDERS OF LIPID DIGESTION AND ABSORPTION: LIPOPROTEIN METABOLISM, PATHOPHYSIOLOGICAL MECHANISMS, AND CLINICAL IMPLICATIONS

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Abstract: Lipids are essential biomolecules that serve as major sources of energy, structural components of cellular membranes, and precursors of biologically active compounds. Efficient digestion, absorption, transport, and metabolism of lipids are fundamental for maintaining metabolic homeostasis. Lipid digestion involves coordinated actions of bile acids, pancreatic enzymes, intestinal epithelial cells, and lipoprotein transport systems. Disturbances in these processes may result in lipid malabsorption, nutritional deficiencies, dyslipidemia, and increased risk of cardiovascular and metabolic diseases. Lipoproteins play a crucial role in the transport of triglycerides, cholesterol, phospholipids, and fat-soluble vitamins throughout the body. Abnormalities in lipoprotein metabolism contribute significantly to atherosclerosis, coronary artery disease, obesity, and metabolic syndrome. This review discusses the physiological mechanisms of lipid digestion and absorption, causes and consequences of malabsorption disorders, lipoprotein metabolism, and their clinical significance. Recent advances in molecular biology and lipidomics have enhanced understanding of lipid-related disorders and opened new avenues for diagnosis and therapeutic intervention.

Keywords: Lipid digestion, lipid absorption, lipoproteins, dyslipidemia, malabsorption syndrome, cholesterol metabolism, atherosclerosis.

Introduction

Lipids are among the most important biological molecules necessary for normal cellular and systemic function. They provide energy, maintain membrane integrity, participate in signal transduction, and serve as precursors for steroid hormones and bioactive mediators.[1,2,3,4]

Unlike carbohydrates and proteins, lipids are hydrophobic molecules that require specialized mechanisms for digestion, absorption, and transport. The gastrointestinal tract, liver, pancreas, lymphatic system, and vascular network work together to ensure efficient lipid utilization.[5,6,7,8]

Disruption of any stage of lipid metabolism can lead to serious pathological consequences. Disorders of lipid digestion and absorption may result in malnutrition and vitamin deficiencies, whereas abnormalities in lipoprotein metabolism are strongly associated with cardiovascular disease and metabolic dysfunction.[9,10,11,12]

Physiological Basis of Lipid Digestion

Lipid digestion is a multistep process involving mechanical, chemical, and enzymatic mechanisms.

Dietary lipids consist primarily of:





Triglycerides

Phospholipids

Cholesterol esters

Fat-soluble vitamins

Approximately 90–95% of dietary lipids are triglycerides.

Gastric Phase of Lipid Digestion

Although lipid digestion occurs predominantly in the small intestine, the stomach initiates this process.[13,14,15,16]

Gastric Lipase

Gastric lipase hydrolyzes triglycerides into:

- Diglycerides
- Free fatty acids

This phase is particularly important in infants because milk fat digestion begins in the stomach.

Mechanical mixing also contributes to emulsification of lipid droplets.

Intestinal Digestion of Lipids

The majority of lipid digestion occurs in the duodenum and jejunum.

Role of Bile Acids

Bile acids synthesized from cholesterol are secreted into the small intestine.

Functions include:

Emulsification of dietary lipids

Formation of micelles

Increased accessibility of lipids to digestive enzymes

Without adequate bile secretion, lipid digestion becomes significantly impaired.[17,18,19,20]

Role of Pancreatic Enzymes

Several pancreatic enzymes participate in lipid digestion.

Pancreatic Lipase

Hydrolyzes triglycerides into:

Monoglycerides

Free fatty acids

Phospholipase A2

Digests phospholipids.

Cholesterol Esterase

Hydrolyzes cholesterol esters and fat-soluble vitamin esters.

These enzymes are essential for efficient intestinal absorption.

Lipid Absorption Mechanisms

Following digestion, lipid products form mixed micelles.

Micelles facilitate transport of:

Fatty acids

Monoglycerides

Cholesterol



Fat-soluble vitamins
to the intestinal epithelial surface.

Within enterocytes:

Lipids are absorbed.

Triglycerides are resynthesized.

Lipoprotein particles are assembled.

The resulting chylomicrons enter lymphatic vessels and subsequently reach systemic circulation.[21,22,23,24]

Disorders of Lipid Digestion and Absorption

Defects in digestion and absorption lead to malabsorption syndromes.

These conditions result in inadequate uptake of dietary lipids and fat-soluble vitamins.

Pancreatic Insufficiency

Pancreatic exocrine dysfunction reduces secretion of digestive enzymes.

Common causes include:

Chronic pancreatitis

Cystic fibrosis

Pancreatic cancer

Pancreatectomy

Consequences include:

Steatorrhea

Weight loss

Nutritional deficiencies

Bile Acid Deficiency

Reduced bile acid availability impairs emulsification.

Causes include:

- Liver disease
- Biliary obstruction
- Gallstone disease
- Ileal resection

Patients often develop impaired absorption of vitamins A, D, E, and K.

Intestinal Disorders

Diseases affecting intestinal mucosa interfere with lipid absorption.[25,26,27,28]

Examples include:

Celiac disease

Crohn's disease

Tropical sprue

Short bowel syndrome

Damage to enterocytes reduces absorptive capacity.

Genetic Disorders

Several inherited diseases affect lipid transport and absorption.

Abetalipoproteinemia

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Caused by mutations affecting microsomal triglyceride transfer protein.

Clinical manifestations include:

- Severe fat malabsorption
- Neurological dysfunction
- Retinal degeneration

Chylomicron Retention Disease

Characterized by impaired chylomicron secretion from enterocytes.

Affected individuals develop growth retardation and vitamin deficiencies.[29,30,31]

Clinical Consequences of Lipid Malabsorption

Persistent lipid malabsorption produces numerous complications.

Nutritional Consequences

Weight loss

Protein-energy malnutrition

Growth retardation

Vitamin Deficiencies

Vitamin A Deficiency

Night blindness

Visual impairment

Vitamin D Deficiency

Osteomalacia

Rickets

Vitamin E Deficiency

Neurological dysfunction

Vitamin K Deficiency

Bleeding disorders

Early diagnosis is essential to prevent irreversible complications.

Lipoprotein Metabolism

Because lipids are insoluble in water, specialized transport systems are required.

Lipoproteins are macromolecular complexes composed of:

- Lipids
- Apolipoproteins
- Phospholipids
- Cholesterol

These structures transport lipids through the bloodstream.

Classification of Lipoproteins

Lipoproteins are classified according to density.

Chylomicrons

Largest and least dense lipoproteins.

Functions:

Transport dietary triglycerides

Deliver lipids from intestine to tissues

Very-Low-Density Lipoproteins (VLDL)



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Synthesized in the liver.

Functions:

Transport endogenous triglycerides

Intermediate-Density Lipoproteins (IDL)

Represent transitional particles formed during VLDL metabolism.

Low-Density Lipoproteins (LDL)

Major carriers of cholesterol.

Functions:

Deliver cholesterol to peripheral tissues

Elevated LDL levels are strongly associated with atherosclerosis.

High-Density Lipoproteins (HDL)

Functions:

Reverse cholesterol transport

Removal of excess cholesterol from tissues

High HDL concentrations generally confer cardiovascular protection.

Apolipoproteins and Their Functions

Apolipoproteins regulate lipoprotein metabolism.

Important examples include:

ApoA-I

Major structural protein of HDL.

ApoB-100

Required for LDL formation and receptor binding.

ApoB-48

Essential for chylomicron assembly.

ApoC-II

Activates lipoprotein lipase.

ApoE

Mediates lipoprotein clearance by the liver.

Defects in apolipoproteins contribute to dyslipidemia.

Metabolism of Chylomicrons

Chylomicrons transport dietary lipids from the intestine.

Following entry into circulation:

1. ApoC-II activates lipoprotein lipase.
2. Triglycerides are hydrolyzed.
3. Fatty acids enter adipose tissue and muscle.
4. Chylomicron remnants are removed by the liver.

This pathway is essential for utilization of dietary fats.

VLDL and LDL Metabolism

The liver synthesizes VLDL particles containing triglycerides and cholesterol.

During circulation:

Triglycerides are removed.

VLDL becomes IDL.



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IDL is converted to LDL.

LDL delivers cholesterol to tissues through receptor-mediated endocytosis.

Excessive LDL accumulation promotes atherogenesis.

HDL Metabolism and Reverse Cholesterol Transport

HDL plays a central role in cholesterol homeostasis.

Functions include:

Collection of excess cholesterol

Transport to the liver

Promotion of cholesterol excretion

HDL also possesses:

Antioxidant activity

Anti-inflammatory properties

Endothelial protective effects

These characteristics contribute to cardiovascular protection.

Disorders of Lipoprotein Metabolism

Abnormal lipoprotein metabolism leads to dyslipidemia.

Common disorders include:

Familial Hypercholesterolemia

Caused by LDL receptor mutations.

Features:

Markedly elevated LDL cholesterol

Premature cardiovascular disease

Familial Combined Hyperlipidemia

Characterized by elevated:

LDL

Triglycerides

It is among the most common inherited lipid disorders.

Hypertriglyceridemia

Associated with:

Obesity

Diabetes mellitus

Alcohol abuse

Severe cases may cause acute pancreatitis.

Lipoproteins and Cardiovascular Disease

Atherosclerosis remains the leading cause of cardiovascular mortality worldwide.

Pathogenesis involves:

1. LDL infiltration into arterial walls.
2. Oxidative modification.
3. Macrophage activation.
4. Foam cell formation.
5. Plaque development.

Protective HDL functions oppose these processes.

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The balance between atherogenic and antiatherogenic lipoproteins significantly influences cardiovascular risk.[32,33,34]

Modern Advances in Lipid Research

Recent developments have improved understanding of lipid metabolism.

Key innovations include:

Lipidomics

Genomic profiling

PCSK9 inhibitors

RNA-based therapeutics

Precision medicine

These advances provide new opportunities for personalized treatment of lipid disorders.[35,36]

Conclusion

Lipid digestion, absorption, and transport are highly coordinated physiological processes essential for maintaining metabolic homeostasis. Disorders affecting these mechanisms result in malabsorption syndromes, nutritional deficiencies, and systemic complications. Lipoproteins serve as indispensable carriers of lipids throughout the body, and abnormalities in their metabolism contribute significantly to cardiovascular and metabolic diseases. Advances in molecular biology and clinical lipidology continue to improve understanding of these disorders and support the development of innovative therapeutic strategies aimed at reducing disease burden and improving patient outcomes.

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THE DEPENDENCE OF BIOLOGICAL FUNCTIONS OF PROTEINS ON THEIR THREE-DIMENSIONAL CONFIGURATION AND METHODS OF PROTEIN ANALYSIS

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Abstract: Proteins are fundamental biological macromolecules responsible for virtually all cellular processes. The biological activity of proteins is directly determined by their three-dimensional conformation, which arises from hierarchical levels of structural organization including primary, secondary, tertiary, and quaternary structures. Alterations in protein conformation may significantly affect enzymatic activity, signal transduction, molecular recognition, and cellular regulation. Understanding the relationship between protein structure and function is therefore essential in modern molecular biology, biochemistry, medicine, and biotechnology. This review examines the dependence of protein biological functions on spatial configuration and provides a comprehensive overview of contemporary analytical techniques employed in protein characterization, including electrophoretic, spectroscopic, chromatographic, mass spectrometric, and structural biology approaches. Recent advances in cryo-electron microscopy, nuclear magnetic resonance spectroscopy, and artificial intelligence-based structural prediction are also discussed. The integration of multiple analytical methodologies has substantially improved our ability to investigate protein dynamics, folding mechanisms, and structure-function relationships.

Keywords: proteins, protein structure, protein function, tertiary structure, protein folding, mass spectrometry, chromatography, spectroscopy, cryo-EM.

1. Introduction

Proteins represent the most versatile class of biomolecules in living organisms. They perform catalytic, structural, transport, regulatory, defensive, and signaling functions essential for cellular survival and homeostasis. The biological activity of proteins depends not only on their amino acid sequence but also on their specific three-dimensional organization. [1,2,3,4,5] The classical principle that "structure determines function" remains one of the central concepts of molecular biology. Even minor alterations in protein conformation may lead to significant functional consequences, including loss of enzymatic activity and development of pathological conditions. Modern structural biology has demonstrated that proteins exist as dynamic molecules whose conformational flexibility is crucial for their biological roles.[6,7,8,9,10]

Understanding protein structure-function relationships has become increasingly important in drug development, disease diagnostics, proteomics, and biotechnology. Advances in analytical technologies have enabled researchers to characterize protein structures at atomic resolution and investigate conformational changes associated with biological activity.[11,12]



2. Structural Organization of Proteins

2.1 Primary Structure

The primary structure of a protein consists of a linear sequence of amino acids connected through peptide bonds. This sequence is genetically encoded and determines all higher levels of protein organization. The physicochemical properties of amino acid residues influence folding pathways and final conformational states.[13,14,15,16]

2.2 Secondary Structure

Secondary structures are stabilized primarily by hydrogen bonds formed between peptide backbone atoms. The most common motifs include α -helices, β -sheets, and random coils. These structural elements provide the fundamental framework for protein folding and contribute to molecular stability. Spectroscopic studies have demonstrated that alterations in secondary structure often correlate with changes in protein functionality.[17,18,19,20]

2.3 Tertiary Structure

The tertiary structure refers to the three-dimensional arrangement of secondary structural elements within a single polypeptide chain. It is stabilized by hydrophobic interactions, hydrogen bonds, ionic interactions, van der Waals forces, and disulfide bridges. Tertiary structure formation generates active sites, ligand-binding pockets, and interaction surfaces that determine biological function.[21,22,23]

2.4 Quaternary Structure

Many proteins function as complexes composed of multiple polypeptide chains. Quaternary structure describes the spatial arrangement of these subunits. Hemoglobin represents a classical example in which cooperative oxygen binding depends on quaternary structural organization.[24,25,26,27]

3. Relationship Between Protein Spatial Configuration and Biological Function

3.1 Enzymatic Activity

Enzymes exhibit highly specific catalytic activity due to the precise organization of amino acid residues within their active sites. The three-dimensional arrangement enables substrate recognition and catalysis. Conformational alterations caused by mutations, environmental stress, or denaturation can impair enzymatic efficiency.[28,29]

3.2 Molecular Recognition and Signal Transduction

Protein-protein interactions and receptor-ligand binding rely on structural complementarity. Cellular signaling pathways require proteins to adopt specific conformational states that facilitate interaction with target molecules. Dynamic structural changes often serve as regulatory mechanisms controlling biological responses.[30,31]

3.3 Transport Functions

Transport proteins such as hemoglobin, albumin, and membrane channels depend on conformational flexibility to bind and release molecules. Structural transitions facilitate selective transport of ions, gases, and metabolites across biological membranes.[32,33]

3.4 Structural and Mechanical Functions



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Collagen, keratin, elastin, and cytoskeletal proteins derive their mechanical properties from highly organized structural arrangements. The integrity of connective tissues and cellular architecture depends on maintenance of these conformations.

3.5 Protein Misfolding and Disease

Incorrect protein folding is associated with numerous pathological conditions, including Alzheimer's disease, Parkinson's disease, Huntington's disease, and prion disorders. Protein aggregation resulting from conformational instability can disrupt cellular function and induce toxicity. Understanding folding mechanisms therefore represents a major objective of biomedical research.[34,35]

4. Protein Folding and Conformational Dynamics

Protein folding is a spontaneous thermodynamic process whereby a polypeptide chain adopts its biologically active conformation. Molecular chaperones assist folding by preventing aggregation and facilitating attainment of native structures. Contemporary studies indicate that proteins exist as ensembles of conformations rather than static structures. These dynamic fluctuations are essential for biological function and molecular recognition.[36]

5. Methods for Protein Analysis

5.1 Electrophoretic Methods

SDS-PAGE

Sodium dodecyl sulfate-polyacrylamide gel electrophoresis is widely used for protein separation according to molecular weight. The technique enables assessment of protein purity and molecular mass estimation.

Two-Dimensional Electrophoresis

Two-dimensional gel electrophoresis combines isoelectric focusing and SDS-PAGE, allowing high-resolution separation of complex protein mixtures.

5.2 Chromatographic Methods

Size Exclusion Chromatography

This method separates proteins according to molecular size and provides information regarding oligomerization and aggregation states.

Ion Exchange Chromatography

Proteins are separated based on charge differences, making the technique useful for purification and characterization.

Affinity Chromatography

Affinity chromatography exploits specific molecular interactions to isolate target proteins with high selectivity.

5.3 Spectroscopic Methods

Circular Dichroism Spectroscopy

Circular dichroism is extensively used for rapid assessment of protein secondary structure content and conformational changes. The method can detect α -helical and β -sheet content in solution.

Fourier Transform Infrared Spectroscopy



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FTIR spectroscopy analyzes amide bond vibrations and provides information about secondary structural elements and protein conformational changes.

Raman Spectroscopy

Raman spectroscopy offers detailed insights into protein secondary structures and molecular interactions while requiring minimal sample preparation.

Fluorescence Spectroscopy

Fluorescence techniques are highly sensitive for monitoring protein folding, unfolding, interactions, and tertiary structure dynamics.

5.4 Mass Spectrometry

Mass spectrometry has become a cornerstone of proteomics and protein characterization. The technique allows determination of molecular mass, amino acid sequence, post-translational modifications, and protein-protein interactions. Modern approaches such as MALDI-TOF and LC-MS/MS provide exceptional analytical sensitivity and accuracy.

5.5 X-ray Crystallography

X-ray crystallography remains the gold standard for determining atomic-resolution protein structures. The method has generated structural information for hundreds of thousands of proteins and protein complexes.

5.6 Nuclear Magnetic Resonance Spectroscopy

NMR spectroscopy provides structural and dynamic information about proteins in solution. Unlike crystallographic methods, NMR enables investigation of protein flexibility and molecular interactions under near-physiological conditions.

5.7 Cryo-Electron Microscopy

Cryo-electron microscopy has revolutionized structural biology by enabling visualization of large protein complexes at near-atomic resolution without crystallization. This technology has significantly expanded our understanding of membrane proteins and macromolecular assemblies.

6. Emerging Technologies and Artificial Intelligence in Protein Analysis

Recent advances in machine learning and artificial intelligence have transformed protein structure prediction. Computational approaches can now predict three-dimensional structures from amino acid sequences with remarkable accuracy. These developments accelerate drug discovery, protein engineering, and understanding of disease mechanisms.

Conclusion

The biological functions of proteins are intrinsically linked to their three-dimensional configuration. Structural organization at primary, secondary, tertiary, and quaternary levels determines molecular recognition, catalytic activity, transport capacity, and regulatory functions. Modern analytical techniques, including spectroscopy, chromatography, mass spectrometry, X-ray crystallography, NMR spectroscopy, and cryo-electron microscopy, provide complementary information necessary for comprehensive protein characterization. Future integration of experimental and computational approaches is expected to further advance our understanding of protein structure-function relationships and facilitate development of novel therapeutic strategies.



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END PRODUCTS OF NITROGEN METABOLISM AND DISORDERS OF UREA SYNTHESIS AND EXCRETION: BIOCHEMICAL MECHANISMS, CLINICAL MANIFESTATIONS, AND MODERN PERSPECTIVES

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Abstract Nitrogen metabolism is a fundamental component of human physiology, ensuring the utilization of amino acids for protein synthesis while facilitating the safe elimination of excess nitrogen. The principal end products of nitrogen metabolism include urea, ammonia, uric acid, and creatinine. Among these compounds, urea serves as the primary route for nitrogen disposal in mammals through the hepatic urea cycle. Efficient urea synthesis and renal excretion are essential for maintaining nitrogen balance and preventing toxic accumulation of ammonia. Disorders affecting urea synthesis or excretion may result in hyperammonemia, hepatic encephalopathy, metabolic disturbances, and life-threatening neurological complications. Inherited urea cycle disorders and acquired liver or kidney diseases represent major causes of impaired nitrogen elimination. Recent advances in molecular genetics, metabolomics, and targeted therapies have improved understanding, diagnosis, and management of these conditions. This review discusses the biochemical basis of nitrogen metabolism, physiological roles of its end products, mechanisms of urea synthesis, disorders of urea production and excretion, and current therapeutic approaches.

Keywords: nitrogen metabolism, urea cycle, ammonia, urea synthesis, hyperammonemia, hepatic encephalopathy, urea cycle disorders.

Introduction

Nitrogen is an essential component of amino acids, proteins, nucleic acids, neurotransmitters, and numerous biologically active compounds. Continuous protein turnover generates nitrogen-containing waste products that must be efficiently eliminated to maintain metabolic homeostasis.[1,2,3,4,5,6,7]

Unlike carbohydrates and lipids, amino acid catabolism produces nitrogenous compounds that can be toxic if allowed to accumulate. Consequently, mammals have evolved specialized pathways for nitrogen disposal, primarily through conversion of ammonia into urea within the liver.[8,9,10,11]

The liver and kidneys function cooperatively to maintain nitrogen balance. The liver detoxifies ammonia by synthesizing urea, whereas the kidneys excrete urea and other nitrogenous waste products through urine. Disruption of these processes may result in severe metabolic abnormalities and organ dysfunction. The urea cycle is the principal mechanism for removal of excess nitrogen and prevention of ammonia toxicity.[12,13,14,15]

Overview of Nitrogen Metabolism

Nitrogen metabolism encompasses the processes involved in:

- Amino acid synthesis



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- Protein turnover
- Nitrogen transport
- Ammonia detoxification
- Waste product excretion

Proteins undergo continuous degradation and resynthesis throughout life. During amino acid catabolism, amino groups are removed through transamination and deamination reactions, generating free ammonia.[16,17,18]

Because ammonia is highly toxic, particularly to the central nervous system, rapid conversion into less toxic compounds is essential. The liver plays a central role in this detoxification process.

Major End Products of Nitrogen Metabolism

Urea

Urea is the principal nitrogenous waste product in humans.

Characteristics include:

Synthesized in the liver

Water-soluble

Relatively non-toxic

Excreted primarily by kidneys

Approximately 80–90% of waste nitrogen is eliminated as urea.

Urea formation represents the most important mechanism for ammonia detoxification.

Ammonia

Ammonia is produced during:

Amino acid deamination

Intestinal bacterial metabolism

Purine and pyrimidine degradation

Although essential as a metabolic intermediate, elevated ammonia concentrations are highly neurotoxic.[19,20,21,22]

Under normal conditions, ammonia is rapidly incorporated into urea or glutamine.

Uric Acid

Uric acid is the final product of purine metabolism.

Functions include:

Nitrogen elimination

Antioxidant activity

Excessive uric acid accumulation may lead to:

Hyperuricemia

Gout

Urolithiasis

Creatinine

Creatinine originates from creatine phosphate metabolism in skeletal muscle.

It serves as an important indicator of renal function because its production rate remains relatively constant.[23,24,25,26]



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Nitrogen Transport in the Body

Before entering the urea cycle, nitrogen must be transported safely from peripheral tissues to the liver.

The principal transport forms include:

Glutamine

Glutamine serves as the major carrier of ammonia from tissues to the liver.

Alanine

Alanine transports nitrogen from skeletal muscles during fasting and exercise.

These mechanisms minimize exposure of tissues to free ammonia.

Urea Synthesis: The Urea Cycle

The urea cycle represents the primary pathway for ammonia detoxification.

It occurs exclusively in hepatocytes and involves both mitochondrial and cytoplasmic reactions. The liver is the only organ capable of completing the entire cycle.[27,28,29,30]

Biochemical Steps of the Urea Cycle

The cycle consists of five major enzymatic reactions.

Step 1: Carbamoyl Phosphate Formation

Enzyme:

Carbamoyl phosphate synthetase I (CPS I)

This rate-limiting reaction combines:

Ammonia

Carbon dioxide

ATP

Step 2: Citrulline Formation

Enzyme:

Ornithine transcarbamylase (OTC)

Carbamoyl phosphate reacts with ornithine to form citrulline.

Step 3: Argininosuccinate Formation

Enzyme:

Argininosuccinate synthetase

Citrulline combines with aspartate.

Step 4: Arginine Formation

Enzyme:

Argininosuccinate lyase

Produces:

Arginine

Fumarate

Step 5: Urea Formation

Enzyme:

Arginase

Arginine is hydrolyzed to produce:

Urea





Ornithine

Ornithine re-enters the cycle, while urea enters circulation for renal excretion.

Regulation of Urea Synthesis

Urea production is highly regulated according to nitrogen load.

Factors increasing urea synthesis include:

High-protein diets

Starvation

Increased protein catabolism

Glucocorticoid excess

N-acetylglutamate functions as an essential activator of carbamoyl phosphate synthetase I.

Renal Excretion of Urea

Following synthesis, urea enters the bloodstream and is transported to the kidneys.

Renal handling of urea involves:

Glomerular filtration

Tubular reabsorption

Tubular secretion

Urea excretion contributes significantly to urine concentration mechanisms and nitrogen balance.[31,32,33]

Disorders of Urea Synthesis

Impaired urea production results in accumulation of ammonia and other toxic metabolites.

These disorders may be inherited or acquired.

Inherited Urea Cycle Disorders

Urea cycle disorders (UCDs) arise from mutations affecting enzymes or transport proteins involved in the urea cycle. Hyperammonemia is the hallmark of these disorders.

Ornithine Transcarbamylase Deficiency

The most common urea cycle disorder.

Clinical manifestations include:

Hyperammonemia

Vomiting

Seizures

Developmental delay

Coma

Carbamoyl Phosphate Synthetase I Deficiency

Characterized by severe neonatal hyperammonemia.

Affected infants often present within the first days of life.

Argininosuccinate Synthetase Deficiency

Also known as citrullinemia.

Results in elevated plasma citrulline concentrations.

Arginase Deficiency

Associated with:

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Progressive neurological dysfunction

Spasticity

Cognitive impairment

Acquired Disorders of Urea Synthesis

Liver Failure

The liver is the exclusive site of urea synthesis.

Severe liver disease reduces:

Functional hepatocyte mass

Urea production capacity

This results in hyperammonemia and hepatic encephalopathy.

Hepatic Encephalopathy

A major complication of advanced liver disease.

Clinical manifestations include:

Cognitive dysfunction

Confusion

Asterixis

Coma

Ammonia is considered a key neurotoxin involved in pathogenesis.

Disorders of Urea Excretion

Even when urea synthesis remains intact, impaired renal excretion may lead to elevated blood urea concentrations.

Acute Kidney Injury

Reduced glomerular filtration decreases urea clearance.

Consequences include:

- Azotemia
- Fluid imbalance
- Electrolyte disturbances

Chronic Kidney Disease

Progressive nephron loss impairs elimination of nitrogenous waste products.

Clinical features include:

Elevated blood urea nitrogen (BUN)

Uremia

Metabolic acidosis

Hyperammonemia

Hyperammonemia is one of the most dangerous consequences of impaired nitrogen metabolism.

Effects on the nervous system include:

Cerebral edema

Seizures

Cognitive impairment

Coma



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Early recognition is essential because prolonged hyperammonemia may cause irreversible brain injury.

Diagnostic Approaches

Diagnosis involves biochemical and molecular investigations.

Laboratory Tests

Plasma ammonia

Blood urea nitrogen

Serum creatinine

Amino acid profile

Liver function tests

Molecular Diagnostics

Gene sequencing

Mutation analysis

Prenatal diagnosis

Newborn Screening

Early detection improves prognosis in inherited disorders.

Prevention and Treatment

Dietary Management

Strategies include:

Controlled protein intake

Essential amino acid supplementation

Prevention of catabolic states

Pharmacological Therapy

Common agents include:

Sodium benzoate

Sodium phenylbutyrate

Arginine supplementation

Liver Transplantation

May provide definitive treatment for severe urea cycle disorders.

Management of Liver and Kidney Disease

Early treatment of hepatic and renal disorders is essential for preventing complications related to nitrogen retention.[34,35]

Future Perspectives

Emerging therapeutic approaches include:

Gene therapy

Genome editing

Enzyme replacement technologies

Precision medicine

Novel ammonia scavengers

These advances may substantially improve outcomes in patients with inherited and acquired disorders of nitrogen metabolism.[36]

Conclusion



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Nitrogen metabolism is essential for maintaining physiological homeostasis and safe elimination of waste nitrogen generated during amino acid catabolism. Urea represents the principal end product of nitrogen metabolism and serves as the primary mechanism for ammonia detoxification. Proper function of the urea cycle and renal excretion pathways is critical for preventing toxic accumulation of nitrogenous compounds. Disorders affecting urea synthesis or excretion may result in hyperammonemia, neurological dysfunction, hepatic encephalopathy, and renal complications. Advances in molecular diagnostics and targeted therapies continue to improve understanding and management of these disorders.

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THE IMPORTANCE OF CONTENT AND LANGUAGE INTEGRATED LEARNING (CLIL) IN TEACHING ENGLISH

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Abstract. This article examines the significance of Content and Language Integrated Learning (CLIL) in teaching English to students majoring in Uzbek Language and Literature. Contemporary higher education requires future philologists not only to possess professional knowledge in their native language and literature but also to access international academic resources and participate in global scholarly communication. In this regard, CLIL offers an effective pedagogical framework that integrates language learning with disciplinary content. The study discusses the theoretical foundations of CLIL, its contribution to communicative competence, academic literacy, intercultural awareness, and professional development.

Keywords: CLIL, English language teaching, Uzbek language and literature, communicative competence, academic literacy, professional competence, content-based instruction, higher education.

Introduction. The rapid internationalization of higher education has increased the importance of foreign language proficiency among university students. For students majoring in Uzbek Language and Literature, English is no longer merely a foreign language subject but an essential tool for accessing international research, participating in academic discourse, and engaging in intercultural communication.

Traditionally, English courses for philology students have focused on general language skills and grammatical competence [7]. However, such approaches often fail to establish meaningful connections between language learning and students' professional interests. As a result, learners may struggle to transfer language knowledge into academic and professional contexts.

Content and Language Integrated Learning (CLIL) has emerged as an innovative educational approach that addresses this challenge by integrating language learning with subject-specific content [8]. According to Coyle, Hood, and Marsh, CLIL promotes the simultaneous development of content knowledge and language competence, creating more authentic and motivating learning experiences [2, 4].

This article explores the pedagogical value of CLIL in teaching English to students of Uzbek Language and Literature and discusses its potential contribution to professional and communicative competence development.

Literature Review. The theoretical foundations of CLIL are closely associated with communicative, cognitive, and sociocultural approaches to language learning. Marsh



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defines CLIL as an educational approach in which a foreign language is used as a medium for learning both content and language simultaneously [4].

Coyle emphasizes that successful CLIL instruction is based on the integration of four key components: Content, Communication, Cognition, and Culture [1]. This framework encourages learners to acquire knowledge, develop language skills, engage in higher-order thinking, and increase intercultural awareness.

Research has demonstrated that CLIL contributes to vocabulary acquisition, academic literacy, learner motivation, and communicative competence [3]. Moreover, it provides opportunities for authentic language use, which is particularly important in higher education contexts where students are expected to engage with specialized disciplinary knowledge.

Despite extensive research on CLIL in science and technology education, relatively few studies have examined its application in philological disciplines, particularly in the context of teaching English to students specializing in national language and literature programs.

Main Part. Students of Uzbek Language and Literature study linguistics, literary criticism, stylistics, folklore, translation studies, discourse analysis, and cultural studies. Contemporary scholarship in these fields increasingly relies on international research published in English. Therefore, future philologists require not only general English proficiency but also the ability to read academic articles, analyze linguistic theories, compare literary traditions, and communicate professionally in international academic settings [9]. Within a CLIL framework, English lessons can incorporate topics directly related to Uzbek philology. Such content creates authentic communicative situations where English functions as a tool for acquiring and discussing professional knowledge rather than merely an object of study.

One of the major advantages of CLIL is its contribution to academic literacy. Philology students are expected to work with scholarly texts, conduct research, and present academic arguments. Through CLIL-based instruction, students engage with authentic academic materials, including journal articles, conference papers, book chapters, and literary analyses [5]. This exposure develops skills in academic reading, critical analysis, note taking, summarizing, academic writing, oral presentation.

Consequently, learners become better prepared for participation in international academic communities.

CLIL creates opportunities for meaningful communication around subject-specific topics. Instead of discussing general everyday situations, students engage in professional discourse related to linguistics, literature, and culture. For example, learners may debate literary interpretations, analyze linguistic phenomena, compare cultural concepts, or present research findings. Such activities contribute to the development of communicative competence in academically relevant contexts.

The study of language and literature is inherently connected to culture. CLIL enables students to compare Uzbek and English-speaking cultures through literary texts, linguistic phenomena, and cultural practices.



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This comparative perspective promotes intercultural competence, which is increasingly recognized as an essential component of foreign language education in the twenty-first century [6].

Discussion. The implementation of CLIL in English courses for Uzbek Language and Literature students aligns with contemporary competency-based educational paradigms. It supports the development of communicative, cognitive, professional, and intercultural competencies simultaneously. Furthermore, CLIL reflects constructivist learning principles by encouraging active knowledge construction and meaningful engagement with disciplinary content. Rather than memorizing isolated linguistic forms, students use English to explore concepts directly relevant to their academic specialization [5]. However, successful implementation requires appropriate teaching materials, teacher training, and curriculum adaptation. English instructors need sufficient knowledge of philological content, while subject specialists may need support in integrating language objectives into content instruction.

Conclusion. The analysis demonstrates that CLIL offers significant pedagogical benefits for teaching English to students majoring in Uzbek Language and Literature.

Its main advantages include:

1. Integration of language learning with professional content.
2. Development of academic literacy skills.
3. Enhancement of communicative competence.
4. Increased learner motivation and engagement.
5. Promotion of intercultural awareness.
6. Improved access to international academic resources.
7. Strengthening of professional competence among future philologists.

Therefore, CLIL can be considered an effective methodological approach for modernizing English language instruction in Uzbek Language and Literature programs and preparing students for participation in global academic and professional communities.

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MILLIY KONTENTNI BAHOLASH MEZONLARI VA O‘ZBEKISTON OAV
MAKONIDA KONTENT-TAHLIL NATIJALARI

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Milliy kontentni baholashning yagona ilmiy-metodologik mezonlari tizimi hozirgi kungacha to‘liq ishlab chiqilmagan. Bu nazariy va amaliy bo‘shliqni to‘ldirish maqsadida mazkur tezisda muallif tomonidan ishlab chiqilgan besh mezondan iborat baholash tizimi va uning O‘zbekiston OAV makoni materiallariga qo‘llanilishi natijalari taqdim etiladi. Mezonlar tizimi ham xalqaro media-tadqiqotlardagi yondashuvlarga, ham O‘zbekiston OAV makonining o‘ziga xos xususiyatlariga tayangan holda shakllantirildi.

OAV kontentida milliylikning aks etish darajasini baholash uchun quyidagi **besh mezon** belgilandi: **mavzu mezoni** — material milliy mavzularga (til, tarix, urf-odat, qadriyatlar, milliy san‘at, madaniy meros, diaspora, milliy bayramlar, milliy shaxslar) bag‘ishlanganlik darajasi; **til va atamashunoslik mezoni** — sof o‘zbek tilining qo‘llanilishi, milliy atamalardan to‘g‘ri foydalanish, til madaniyatiga rioya etish darajasi; **kontent chuqurligi mezoni** — mavzu yoritilishining tahliliy va dalillangan xarakteri; **ijodiy shakl mezoni** — zamonaviy multimedia (infografika, video, podcast) va ijodiy texnikalardan foydalanish darajasi; **auditoriyaga moslashish mezoni** — auditoriya talab va idrokiga muvofiq kontent shakllantirish.

Har bir mezon bo‘yicha material uchta darajada baholandi: yuqori (barcha talablar to‘liq bajarilganda), o‘rta (talablarning katta qismi bajarilgan, biroq kamchiliklar mavjud), past (talablarning aksariyati bajarilmagan yoki yuzaki bajarilgan). Tahlil 2024-yil sentyabr – 2025-yil aprel oraligida O‘zbekiston OAV makonining yetti yetakchi vakili (O‘zbekiston 24, Madaniyat va ma‘rifat, Yoshlar telekanali, Yangi O‘zbekiston gazetasi, Kun.uz, Daryo.uz, Qalampir.uz) materiallari bo‘yicha amalga oshirildi va jami **624 ta material** kompleks tahlilga jalb qilindi. Kodlash jarayonida ikki mustaqil baholovchi ishtirok etdi, ularning baholari o‘rtasidagi muvofiqlik koeffitsienti (Krippendorff alfa) **0,82** ga teng bo‘lib, bu kontent-tahlil natijalarining yuqori ishonchliligini ta‘minladi.

Kontent-tahlil natijalari quyidagicha umumlashtirildi. Tahlilga olingan 624 ta materialdan 215 tasi (34,5%) milliylik mezonlari bo‘yicha «yuqori» darajada, 268 tasi (43,0%) — «o‘rta» darajada, 141 tasi (22,5%) — «past» darajada baholandi. Bu umumiy taqsimot O‘zbekiston OAV makonida milliy kontentning sezilarli ulushini ko‘rsatadi, biroq sifat va chuqurlik nuqtai nazaridan jiddiy rivojlanish imkoniyatlari mavjud ekanini namoyon etadi.

OAVlar kesimida tahlil muhim nomutanosiblikni aniqladi. Ixtisoslashgan «Madaniyat va ma‘rifat» telekanali milliy kontent sifat ko‘rsatkichlari bo‘yicha yetakchilikni egallaydi (yuqori daraja — **64,2%**), ammo uning auditoriyasi nisbatan tor. Yetakchi internet-nashrlar (Kun.uz, Daryo.uz, Qalampir.uz) keng auditoriyaga ega bo‘lsa-da, ulardagi milliy kontent ulushi pastroq darajada — **18,9%–24,5% yuqori daraja**. Bu O‘zbekiston media-makonidagi jiddiy nomutanosiblikni ko‘rsatadi: keng auditoriyaga ega

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platformalarda milliy kontent yetarli chuqurlikda va kasbiy sifatda taqdim etilmaydi, ixtisoslashgan kanallarda esa sifat yuqori, biroq qamrov cheklangan.

Olib borilgan kontent-tahlil quyidagi xulosalarni asoslash imkonini berdi: birinchidan, O'zbekiston OAV makonida milliy kontent mavjud, biroq uning sifati va auditoriyaga moslashish darajasi jiddiy yaxshilanishga muhtoj; ikkinchidan, keng auditoriyaga ega raqamli platformalarda milliy kontent ulushini bosqichma-bosqich oshirish ustuvor vazifa hisoblanadi; uchinchidan, taklif etilayotgan besh mezonli baholash tizimi milliy axborot siyosatini monitoring qilish va kontent sifatini izchil baholash uchun ilmiy-metodologik vosita sifatida xizmat qilishi mumkin.

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