

MINISTRY OF HEALTH OF UKRAINE
OSCE NATIONAL MEDICAL UNIVERSITY
Department of Biophysics, Informatics and Medical Equipment



Vice-Rector on Educational and Pedagogic Work

Prof.

APPROVED

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“20” august 2021

SUBJECT PROGRAM FOR THE COURSE

"MODERN PROBLEMS OF BIOPHYSICS"

Level of Higher Education: Second (Master's)

Field of knowledge: 22 "Health Care"

Specialty: 221 "Dentistry"

Educational qualification: Dentistry

Odessa 2021-2022

Composed on the basis of the educational-professional program of the second level of higher education for the preparation of Masters in the specialty 221 "Stomatology" in ONMedU, approved by the Academic Council of ONMedU in 04.06.2020, Protocol #11.

The program was discussed at a meeting of the Department of Biophysics, Informatics and Medical Devices.

Protocol #1 from August 27, 2021

Head of the Department,



Professor L.S. Godlevsky

The program was approved at a meeting of the Cycle Subject Commission of Biomedical Science of ONMedU.

Protocol #1 from August 30, 2021

Head of the Cycle Subject Commission of Biomedical Science,



Professor O.L. Appelhans

The program was certified at a meeting of the Central Coordination and Methodological Council of ONMedU on August 30, 2021, Protocol #1.

1. Description of the Course

Names of the indexes	Characteristics of the Course	
	Daytime studying	
General number of :	Mandatory	
Credits –3	Year of studying	1
Hours – 90	Semesters	2
Contents blocks - 7	Lectures	10 hrs
	Practices	30 hrs
	Homework	50 hrs
	Individual tasks	0
	Form of final control	test

2. The goal and purpose of the Course

Goal: Formation of students' knowledge of basic physical principles and approaches to the study of biophysical problems, physical and technical principles of medical and technical devices used in practical medicine, the use of mathematical methods in biomedical research, which form the basis of subject competencies in medical and biological physics and is an integral part of the professional competence of the future doctor and healthcare specialist.

- a) phenomena of living nature that occur at all levels of its organization, beginning with molecules and cells and ending with the biosphere as a whole;
- b) Mechanisms of influence of physical fields on the human body, which are the basis for the functioning of modern electronic medical equipment and determine the main principles of its operation and use.

Objective of studying the subject :

Obtain the physical basis of modern methods of biophysics.

Understand the modern principles of synergetic

According to the requirements the goals of the course "Modern problems of Biophysics" are:

To explain the physical principles and biophysical mechanisms of action of external factors (field) on human organism.

To explain the physical basis of diagnostic and physiotherapy (curative) methods used in medical equipment.

To explain the common physical and biophysical principles that underlie human life.

Achieving these goals will allow medical students to master the physical and biophysical, technical and mathematical knowledge and skills necessary to direct the formation of a physician - a professional in his business, and to study other educational theoretical and clinical subjects in higher education system.

The process of learning the discipline is directed to the formation of elements of the following competencies:

Integral competence

IC. Ability to solve typical and complex specialized tasks and problems in the field of health care in the specialty "Dentistry", in professional activities or in the learning process, which involves research and / or innovation and is characterized by complexity and uncertainty of conditions and requirements.

General competencies :

- GC1. Ability to abstract thinking, analysis and synthesis.
- GC2. Knowledge and understanding of the subject area. and understanding of professional activity.
- GC3. Ability to apply knowledge in practice.
- GC4. Ability to communicate in the state language both orally and in writing.
- GC6. Skills in the use of information and communication technologies.
- GK7. Ability to search, process and analyze information on biophysics from various sources.
- GK8. Ability to adapt and act in a new situation
- GC11. The ability to work in a team.
- GC14. The ability to exercise their rights and responsibilities as a member of society, to realize the values of civil (free democratic) society and the need for its sustainable development, the rule of law, human and civil rights and freedoms in Ukraine.
- GC15. Ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, techniques and technologies. active recreation and leading a healthy lifestyle.

Special competencies:

- SC2. Ability to understand the basic physical principles of modern methods of medical and biological examinations.
- SC8. Ability to know the physical basis for the functioning and use of modern (electronic) medical devices their construction and principle of operation.
- SC13. The ability to understand the physical basis and biophysical mechanisms and the effects of influence of physical fields on the human body.

Expected learning results. As a result of studying the Course the student must

To know:

- basics of mathematical processing of medical and biological data;
- general physical and biophysical patterns that underlie the processes occurring in the human body;
- characteristics of physical external factors affecting the human body and biophysical mechanisms of these influences;
- physical and biophysical bases of medical materials science;
- purpose and principles of operation of electronic medical equipment, safety precautions when working with it.

To be able:

- to carry out mathematical and computer processing of medical and biological information;
- use medical equipment used in medicine, diagnostics, electrical stimulation and physiotherapy (in particular, in electrocardiography, rheography, impedance plethysmography, audiometry, optical and quantum mechanical devices and systems, radiometric and dosimetric control devices

3. Contents of the subject plan

Section 1. Subject and basic tasks of biophysics. biomechanics

Topic 1 The relationship of physical and biological processes in living organisms.

Topic 2. Biomechanics of the human dentition.

Section 2.. Objects of research in molecular biophysics. macromolecules

Topic 3. Features of the chemical composition of living matter. The main types of biomolecules, differences in their structure and functions ..

Topic 4. Physical properties of composite materials in dentistry

Topic 5. Biophysics of proteins and nucleic acids

Topic 6. Basic physical properties of macromolecules, molecular weight, chain structure, flexibility. Internal Rotation and Rotational Isometry

Topic 7. Electrophoresis of macromolecules

Topic 8. Adsorption and differential spectrophotometry of proteins

Section 3. . Intermolecular interactions. conformational transformations

Topic 9. Intermolecular interactions and forces that stabilize the structure of biological macromolecules: Coulomb interaction, Van der Waals forces, hydrogen bond and its basic properties, hydrophobic interactions. 4

Topic 10. The method of atom-atomic potentials and methods of studying intermolecular interactions, empirical potentials of interparticle interactions 4

Topic 11. Conformations of macromolecules, Gaussian coils, persistent chains, helical configurations, the relationship between the parameters of real and model chains. 4

Topic 12. Conformational transformations: conformations and partition function; theories of cooperative transitions, the width of the temperature range of transitions, the effect of ionization of macromolecules

Section 4. Macromolecules in a cell ..

Topic 13. Mechanism of action of biologically active compounds on ion channels.2

Topic 14 Factors that have a harmful effect on the cell.

Topic 15. Structural models of water

Topic 16. Modern methods of water purification

Topic 17. Macromolecules in solutions - expression of thermodynamic functions through a partition function, equation of state for macromolecular solutions (lattice model), virial coefficients, theta point, excluded volume,

swelling of a macromolecule, macroions, equation of state in the case of ionization of a macromolecule.

Topic 18. Modeling of intercellular contacts

Section 5. Methods of biophysical research. Physical foundations of imaging techniques in dentistry

Topic 19. Methods for determining the density and volume of biomolecules.

Topic 20. Physical foundations of imaging methods in dentistry

Topic 21. Doppler ultrasound method

Topic 22 General theory of dispersion of optical rotation and circular dichroism

Topic 23. Relay spectroscopy, picosecond spectroscopy

Topic 24-X-ray scattering by atoms, molecules, crystal lattice. Bragg-Wolfe diffraction condition. Reverse lattice concept. Laue diffraction condition. Structure factor equations. The problem of phases in X-ray structural analysis and methods for its solution

Topic 25. Optical methods for studying biological molecules. Small angle X-ray scattering.

Topic 26. Mechanisms of interaction of X-ray radiation with matter.

Section 6. Electron microscopy.

Topic 27. Methods for preparing samples and obtaining contrast images in electron microscopy.

Topic 28. Electron microscopy of viruses and microbes

Section 7. Synergetic principles of biophysics.

Topic 29. Synergetic principles of biophysics

Topic 30. Bifurcations and catastrophes in open biomedical systems

4. Structure of the course

Topics	Hours			
	Total	Including:		
		Lecture	Practice s	IWS
1	2	3	4	5
Section 1: Subject matter and main tasks of biophysics. Biomechanics				
Topic 1 Interrelation of physical and biological processes in living organisms.				4
Theme 2: Biomechanics of the human dental system .		2		2
Section 2: Research Objects in Molecular Biophysics. Macromolecules				
Theme 3: Peculiarities of Chemical Composition of Living Matter. Basic types of biomolecules, differences in their structure and functions.				4
Topic 4: Physical properties of composite materials in dentistry		2		2
Topic 5: Biophysics of Biols and Nucleic Acids		2		
Theme 6: Basic physical properties of macromolecules, molecular weight, lancelike structure, bending. Intrinsic entanglement and rotational imaging				4
Topic 7: Electrophoresis of macromolecules			2	
Topic 8: Adsorption and diffraction spectrophotometry of proteins			2	
Section 3: Intermolecular Interactions. Conformational Transformations				
Topic 9: Intermolecular interactions and forces that stabilize the structure of biological macromolecules: Coulomb interaction, Van der Waals forces, water bonding and its basic properties, hydrophobic interactions.				4
Topic 10. Method of atomic-atomic potentials and methods of studying intermolecular interactions, empirical potentials of inter-particle interactions				4
Topic 11. Macromolecule conformations, Gaussian balls, persistent lancets, spiral configurations,				4

relationship between parameters of real and model lancets.				
Topic 12. Conformational transformations: conformations and statistical sum; theories of cooperative transitions, the width of the temperature interval of transitions, the influence of ionization of macromolecules				4
Section 4 Macromolecules in a cell.				
Topic 13. Mechanism of action of biologically active spores on ionic channels.			2	
Topic 14 Causes that have a negative effect on the cell.			2	
Topic 15. Structural Models of Water			2	
Topic 16. Modern methods of water purification			2	
Topic 17. Macromolecules in solutions - expression of thermodynamic functions through statistical sum, equation of state of macromolecular solutions (graphical model), virtual coefficients, tetra-point, excluded volume, macromolecule swelling, macroions, equation of state in case of ionization of macromolecule.		2		4
Topic 18. Modeling of intracellular contacts			2	
Section 5. Methods of Biophysical Investigations. Physical bases of visualization methods in dentistry				
Topic 19. Methods for determining the solidity and volume of biomolecules.				4
Topic 20. Physical bases of visualization methods in dentistry		2		
Topic 21. The method of ultrasonic dopplerography			2	
Topic 22 General Theory of Dispersion of Optical Wrapping and Colic Dichroism			2	
Topic 23. Relay spectroscopy, picosecond spectroscopy			2	
Topic 24-Ray diffraction by atoms, molecules, and crystal grains. The condition of Bragg-Wolfe diffraction. The notion of a bell-shaped graph. The condition of Laue's diffraction. The structural factor equation. The Problem of Phases in X-ray Structure Analysis and Methods of its Solution				4

Topic 25. Optical methods of investigation of biologic molecules. Small-cut X-ray dissociation.				4
Topic 26. Mechanisms of interaction of X-ray imaging with a substance.			2	
Section 6: Electron Microscopy.				
Topic 27. Methods of making images and obtaining contrasting images in electron microscopy.			2	
Topic 28. Electron microscopy of viruses and microbes			2	
Section 7 Synergetic Principles of Biophysics.				
Topic 29. Synergetic principles of biophysics			2	
Topic 30. Bifurcations and catastrophes in open medical and biological systems			2	
Preparing for the hall				2
Individual tasks	-	-	-	-
Total	90	10	30	50

5. LECTURE PLAN

№	Topic of the lecture	Hours
1	Biological macromolecules in solutions	2
2	Biomechanics of the human dental system.	2
3	Physical properties of composite materials in dentistry	2
4	Biophysics of proteins and nucleic acids	2
5	Physical foundations of imaging techniques in dentistry	2
	Total	10

6. PRACTICE PLAN

	Topics of the class and its contents	Volume of the year
1	Electrophoresis of macromolecules	2
2	Structural water models	2
3	Modern methods of water purification	2
4	Absorption and differential spectrophotometry of proteins	2
5	Mechanism of action of biologically active compounds on ion channels	2
6	Factors that have a harmful effect on the cell	2
7	Modeling of intracellular contacts	2
8	Bifurcations and catastrophes in open biomedical systems	2
9	Doppler ultrasound method	2
10	Methods for preparing samples and obtaining contrast images in electron microscopy	2
11	Electron microscopy of viruses and microbes	2
12	Mechanisms of the interaction of X-ray radiation with matter	2
13	General theory of dispersion of optical rotation and circular dichroism	2
14	Relay spectroscopy, picosecond spectroscopy	2
15	Synergetic principles of biophysics	2
	Total	30

7. Individual Work of Students (IWS)

№	IWS topics	Hours
1	The subject and main tasks of biophysics. The relationship between physical and biological processes in living organisms. The history of development and modern trends in the development of biophysics. Using the results of biophysical research in practice	4
2	Biomechanics of the human dental system	2
3	Research objects in molecular biophysics. Features of the chemical composition of living matter. The main types of biomolecules, differences in their structure and functions	4
4	Physical properties of composite materials in dentistry	2
5	Intermolecular interactions and forces that stabilize the structure of biological macromolecules: Coulomb interaction, Van der Waals forces, hydrogen bond and its basic properties, hydrophobic interactions	4
6	Method of atomic-atomic potentials and methods of studying intermolecular interactions, empirical potentials of inter-particle interactions.	4
7	Basic physical properties of macromolecules, molecular weight, chain structure, flexibility. Internal rotation and rotational isometry	4
8	Conformations of macromolecules, Gaussian coils, persistent chains, helical configurations, the relationship between the parameters of real and model chains	4
9	Conformational transformations: conformations and partition function; theories of cooperative transitions, the width of the temperature range of transitions, the effect of ionization of macromolecules	4
10	Macromolecules in solutions - expression of thermodynamic functions through a partition function, equation of state for macromolecular solutions (lattice model), virial coefficients, theta point, excluded volume, swelling of macromolecules,	4

	macroions, equation of state in the case of ionization of a macromolecule	
11	Methods for determining the density and volume of biomolecules	4
12	Optical methods for studying biological molecules. Small angle X-ray scattering	4
13	X-ray scattering by atoms, molecules, crystal lattice. Bragg-Wolfe diffraction condition. Reverse lattice concept. Laue diffraction condition. Structure factor equations. The problem of phases in X-ray structural analysis and methods for its solution	4
14	Preparing for the test	2
	Total.	50

8. Individual tasks

Students works on all topics under the guidance of teachers. Quality of their work is considered when the final grade for the entire course of medical and biological physics for a student is produced.

9. Methods of studying

Practical classes: study of material from textbooks and manuals

. Interviewing students and a teacher's conversation with them, with the identification of fragments of material that seem difficult and unclear to them.

An explanation by the teacher of these parts of the material, with an illustration of their practical significance in medicine.

Completion of the assignments set by the teacher in the classroom, with their verification and clarification of errors.

10. Methods of control and criteria for evaluating learning outcomes

Assessment of current educational activities, one practical lesson:

Evaluation of the success of the study of each topic of the discipline is performed on a traditional 4-point scale.

At least 50% of students should be interviewed in a practical (laboratory) lesson, and at least 30% in a seminar.

At the end of the semester (cycle), the number of grades for students in the group should be the same on average.

At the end of the course, the current performance is calculated as the average current score, ie the arithmetic mean of all grades obtained by the student on a traditional scale, rounded to 2 (two) decimal places, for example 4.75.

«5»	The student is fluent in the material, takes an active part in discussing the problems presented in class, confidently demonstrates analytical skills during the class and interpretation of the provided model data of laboratory and instrumental research, expresses his opinion on the topic, demonstrates scientific and analytical thinking.
«4»	The student is well versed in the material, participates in the discussion of problems presented in class, demonstrates analytical skills during the class and interpretation of the provided model data of laboratory and instrumental research with some errors, expresses his opinion on the topic, demonstrates scientific and analytical thinking.
«3»	The student does not have enough material, insecurely participates in the discussion of problems presented in class, demonstrates analytical skills during class and interpretation of the provided model data of laboratory and instrumental studies with significant errors.
«2»	The student does not own the material, does not participate in the discussion of problems presented in class, does not demonstrate analytical skills during class and interpretation of the provided model data of laboratory and instrumental research.

At the last practical lesson, the teacher is obliged to announce to students the results of their current academic performance, and their academic debt (if any). Only those students who do not have academic debt and have an average score of at least 3.00 for current academic activities are allowed to take the final certification.

Final control of knowledge in the course.

Criteria for evaluating the learning outcomes of students on a differentiated test:

«5»	It is presented to a student who systematically worked during the semester, showed during the exam versatile and deep knowledge of the program, is able to successfully perform the tasks provided by the program, mastered the content of basic and additional literature, realized the relationship of individual sections of the discipline, their importance for future profession. showed creative abilities in understanding and using educational material, showed the ability to independently update and replenish knowledge; level of competence - high (creative);
«4»	It is presented to a student who has shown full knowledge of the curriculum, successfully performs the tasks provided by the program, mastered the basic literature recommended by the program, showed a sufficient level of knowledge in the discipline and is able to independently update and update during further study and professional activities; level of competence - sufficient (constructive-variable)
«3»	It is presented to a student who has shown knowledge of the basic curriculum in the amount necessary for further study and further work in the profession, copes with the tasks provided by the program, made some mistakes in answering the exam and when performing exam tasks, but has the necessary knowledge to overcoming mistakes under the guidance of a research and teaching staff; level of competence - average (reproductive)
«2»	It is presented to a student who did not show sufficient knowledge of the basic curriculum, made fundamental mistakes in performing the tasks provided by the program, can not without the help of the teacher to use the knowledge in further study, failed to master the skills of independent work; level of competence - low (receptive-productive).

11. Distribution of points received by applicants for higher education

The grade for the course consists of 50.0% of the grade for the current performance and 50.0% of the grade for the exam. The average score for the course is translated into a national grade and converted into scores on a multi-point scale. Conversion of the traditional grade for the course in the 200-point is carried out by the information and computer center of the University program "Contingent".

Table for conversion of traditional assessment into multi-point:

National mark for the course	Total scores for the course
«5»	185 – 200
«4»	151 – 184
«3»	120 – 150

Points from the discipline are independently converted into both the ECTS scale and the four-point scale. ECTS scale scores are not converted to a four-point scale and vice versa. Further accounts are carried out by the information and computer center of the university

Table for conversion of traditional assessment and the sum of scores to the ECTS

ECTS scores	Statistical distribution
A	Best 10% of students
B	Next 25% of students
C	Next 30% of students
D	Next 25% of students
E	Next 10% of students

The ECTS scale is given by the ONMedU educational subdivision or the dean's office after ranking the grades in the discipline among students studying in one course and in one specialty. According to the decision of the Academic Council, it is recommended to rank students - citizens of foreign countries in one array.

12. Questions for the final control

1. Electrophoresis of macromolecules.
2. Structural models of water.
3. Modern methods of water purification.
4. absorption spectrophotometry of proteins.
5. Differential spectrophotometry of proteins
6. The mechanism of action of biologically active compounds on ion channels.
7. Factors that have a harmful effect on the cell.
8. Modeling of intercellular contacts.
9. bifurcations and catastrophes in open biomedical systems.
10. Doppler ultrasound method.
11. Methods for preparing samples and obtaining contrast images in electron microscopy.
12. Electron microscopy of viruses and microbes.
13. Mechanisms of interaction of X-ray radiation with matter.
14. General theory of dispersion of optical rotation and circular dichroism.
15. Relay spectroscopy, picosecond spectroscopy.
16. synergetic principles of biophysics
17. Biological macromolecules in solutions.
18. Biophysics of proteins and nucleic acids.
19. Physical foundations of imaging methods in medical diagnostics.
20. Physical foundations of modern methods of research of substances
21. swelling of macromolecules.
22. Properties of high molecular weight compounds
23. Chromatographic separation methods
24. Physical properties of synthetic materials in dentistry
25. intermolecular interaction and strength, x
26. Basic physical properties of macromolecules, molecular weight, chain structure, flexibility.
27. Internal rotation
28. rotary isometry.
29. conformation of macromolecules, Gaussian coils, persistent chains, helical configurations.
30. The relationship between the parameters of real and model chains.
31. Conformational transformations: conformation and partition function;
32. Theories of cooperative transitions,
33. The width of the temperature range of transitions,
34. Influence of ionization of macromolecules.
35. Macromolecules in solutions -
36. Equation of state of macromolecular solutions (lattice model),

37. Virial coefficients, theta point, swelling of macromolecules, macroions,
38. Equation of state in the case of ionization of a macromolecule.
39. Bragg-Wolfe diffraction condition.
40. The concept of a reciprocal lattice.
41. Laue diffraction condition.
42. Equation of the structural factor.
43. The problem of phases in structural analysis and methods of its solution
44. Subject and main tasks of biophysics.
45. The relationship of physical and biological processes in living organisms
46. The history of development and modern trends in the development of biophysics.
47. Using the results of biophysical research in practice
48. Biomechanics of the human dentition
49. Objects of research in molecular biophysics.
50. Features of the chemical composition of living matter.
51. The main types of biomolecules, differences in their structure and functions
52. Physical properties of composite materials in dentistry
53. intermolecular interactions and forces that stabilize the structure of biological macromolecules
54. Coulomb interaction,
55. Forces of Van der Waals,
56. Hydrogen bond and its main properties,
57. hydrophobic interactions
58. The method of atom-atomic potentials and methods of studying intermolecular interactions, empirical potentials of interparticle interactions.
59. Methods for determining the density and volume of biomolecules
60. Optical methods for studying biological molecules.
61. Small-angle X-ray scattering
62. X-ray scattering by atoms, molecules, crystal lattice.
63. The mechanism of action of biologically active compounds on ion channels
64. Factors that have a harmful effect on the cell
65. Modeling intercellular contacts
66. Bifurcations and catastrophes in open biomedical systems
67. Doppler ultrasound method
68. Methods for preparing samples and obtaining contrast images in electron microscopy
69. Electron microscopy of viruses and microbes
70. Mechanisms of interaction of X-ray radiation with matter.
71. General theory of dispersion of optical rotation
72. Circular dichroism
73. Relay spectroscopy, picosecond spectroscopy
- 74 synergistic principles of biophysics

75. Resonant methods of quantum mechanics.
76. Mechanisms of absorption and scattering of light.
77. Dispersion.
78. concentration colorimetry,
79. Photometry.
80. Fluorescence analysis in medicine
81. Measurement of the size of micro-objects using an optical microscope.
82. refractometric method for measuring the dependence of the refractive index of a solution on its concentration

13. Methodological support

Working program of the course
The syllabus of the course
Multimedia presentations
Methodical units for practical classes
Electronic test bank

14. Recommended literature

Basic:

1. Intermediate Physics for Medicine and Biology / Russell K. Hobbie (Author), Bradley J. Roth. — 5th ed. — Springer Science+Business Media, 2015. — ISBN-13: 978-3319126814, ISBN-10: 3319126814
2. Compendium of Biophysics / Andrey B. Rubin First © 2017 Scrivener Publishing LLC ISBN:9781119160250 |Online ISBN:9781119160281 |DOI:10.1002/9781119160281

Additional:

1. Biophysics: An Introduction / Roland Glaser. Springer-Verlag Berlin Heidelberg, 2012. ISBN 978-3-642-25212-9
2. Physics in Biology and Medicine - 5th Edition / Paul Davidovits. Academic Press, 2018. ISBN: 9780128137178
3. Membrane Structural Biology With Biochemical and Biophysical Foundations 2nd Edition / Mary Luckey, San Francisco State University, 2014 ISBN: 9781107030633
4. Biophysics: Tools and Techniques / Betty Karasek. East West Books, 2017. ISBN-13: 978-1632385444. ISBN-10: 1632385449

15. Online resources

1. <https://info.odmu.edu.ua/chair/biophysics/files/428/en> (Methodic resources of the department)
2. <http://amphu.org> (Medical Physics in Ukraine)
3. <http://uamedphys.blogspot.com> (Books on Medical Physics)
4. <http://iopscience.iop.org/0031-9155> (Journal of Physics in Medicine and Biology)
5. <http://mednavigator.net> (Medical search engine)
6. <https://physicsworld.com/c/medical-physics> (Information resources of medical and biological physics)
7. <http://iomp.org> (International Organization of Medical Physics)
8. <https://aapm.org/default.asp> (Website of the American Association of Physicists in Medicine)
9. <https://aapm.onlinelibrary.wiley.com/journal/24734209> ((Journal «Medical Physics»))
10. <https://efomp.org> (Website of the European Federation of Medical Physicists)
11. <https://www.facebook.com/AmericanMedicalAssociation/> (American Medical Association)