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DACE DENTAL ACADEMY of CONTINUING EDUCATION

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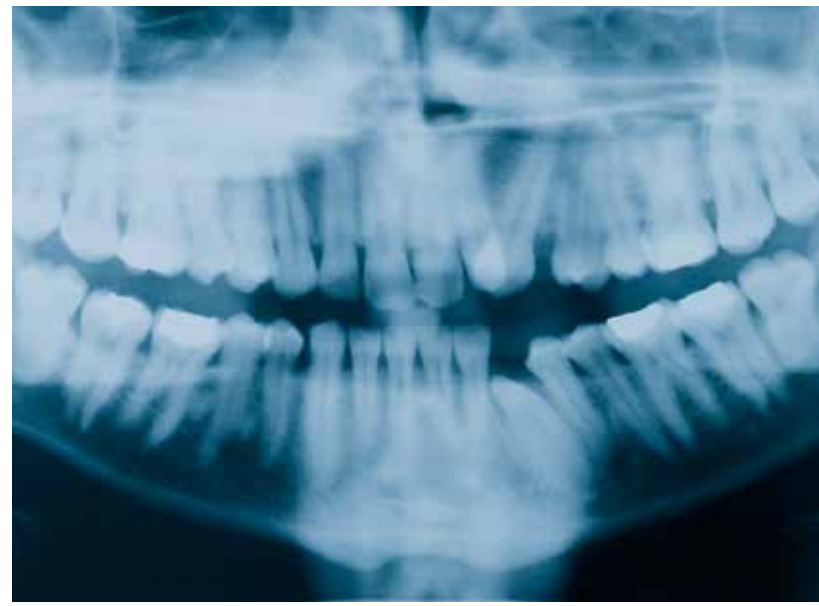

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ABSTRACT

This course will discuss the discovery of radiation, how it works and is absorbed in the body, and technological developments over the last century, to enable the clinician to understand the radiological concept and be better able to explain to patients the purpose and importance of acquiring radiographs. Dental clinicians will learn how to discuss safety protocols with patients. By obtaining qualitative diagnostic radiographs to treatment plan and perform optimal dental treatment, unnecessary health care and dental costs can be reduced. Dental radiographs are also useful for detecting pathology that is undetectable with a clinical oral exam, identifying plaques in the carotid artery, and assisting in human identification in dental forensics.

EDUCATIONAL OBJECTIVES

1. Define radiation and explain how radiation exposure is measured.
2. Identify x-ray components and their functions.
3. Identify key innovators in the discovery of radiation.
4. Define the ALARA philosophy.

Are you curie-ous about radiation?

A PEER-REVIEWED ARTICLE | by Lacy Walker, BS, RDH, CDA, MAADH, FAAOSH

Dental radiographs are one of the most frequently performed types of imaging that complement the clinical examination. They assist dental professionals in accurately diagnosing odontogenic issues and periodontal and periapical pathologies. According to the Centers for Disease Control and Prevention (CDC), radiation is a form of electromagnetic wave; it is "energy that comes from a source and travels through space at the speed of light."[1] This energy has an electric and magnetic field associated with it and has wavelike properties.[1]

Nature contains a wide range of electromagnetic radiation; one type is visible light. Radiation with the highest energy includes ultraviolet, x-rays, and gamma rays **(figure 1).**[1] X-rays and gamma rays have so much energy that "when they interact with atoms, they can remove electrons and cause the atom to become ionized."[1]

X-rays are a type of ionizing radiation and are a form of energy that removes electrons from atoms and molecules of materials, including air, water, and living tissue.[1] Use of ionizing radiation for diagnostic imaging has increased over the last few decades. "Ionization is the process by which an atom or a molecule acquires a negative or

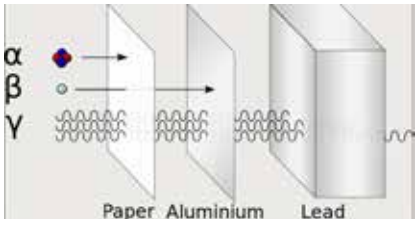

FIGURE 1. This demonstrates the ability of different kinds of ionizing radiation to penetrate matter. Alpha particles are stopped by a sheet of paper while beta particles stop at an aluminum plate. Gamma radiation is dampened when it penetrates matter.

Wikimedia, Alfa beta gamma radiation.svg: Stannered / derivative work: Ehamberg, Cc-by-2.5, Cc-by-sa-3.0-migrated, GFDL

positive charge by gaining or losing electrons."[2]

The multitude of x-rays taken by health-care professionals in a dental environment is best understood by educating oneself on the science behind radiography and with knowledge of the different radiological terms. Terminology used in describing radiation that is emitted and absorbed includes roentgen equivalent man (rem), radiation absorbed dose (rad), maximum permissible dose (MPD), kilovoltage (kV), becquerels (Bq), curie (Ci), and sievert (Sv).

Radiation terminology

rem (roentgen equivalent man): The international unit of x-radiation or gamma radiation is equal to the amount of radiation produced in one cubic centimeter of dry air at 0°C. The standard atmospheric pressure ionization of either sign equals one electrostatic charge unit.[1] Rem is a unit of effective dose named after the discoverer, William Roentgen, and eventually replaced by the sievert.

rad: "Absorbed dose describes the amount of energy deposited per unit mass in an object or person."[3]

MPD: "Amount of ionizing radiation a person may be exposed to, supposedly without being harmed."[4]

kVp: The highest kilovoltage used in producing a radiograph.[5]

becquerel: "A unit of radioactivity of a given sample of material equal to one atomic decay per second."[6]

curie: A unit of radioactivity equal to 3.7 × 10^10 disintegrations per second.[7]

sievert: The amount of radiation is roughly equivalent in biological effectiveness to 100 rads of gamma radiation. It is named after Rolf Sievert, a Swedish medical physicist famous for his work on radiation dosage measurement.[8]

Radiation physics

Dental radiation physics is the study of how dental radiation works. It involves the properties of dental radiation, its interaction with matter, and its application in dentistry. In the x-ray tube, electrons interact with a target, and the kinetic energy of the electrons is converted into x-rays or electromagnetic energy. The anode is a piece of tungsten heated by an electrical current.[9] The cathode is a piece of tungsten cooled by an electrical current. When the anode and cathode are brought together, they produce x-rays **(figure 2)**.[9]

The cathode includes a tungsten target and a copper stem to supply electrons necessary to generate x-rays. The purpose of the anode is to convert electrons into x-ray photons. The tungsten target consists of a tungsten wire filament made of molybdenum, and it serves as the focal spot and converts bombarding electrons into x-ray photons.[9]

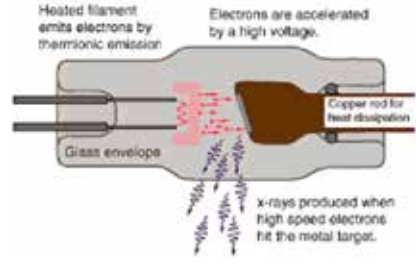

FIGURE 2. Generation of x-rays using the anode and cathode

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A collimator is a metallic barrier with an aperture in the middle used to reduce the x-ray beam's size and shape, thereby reducing the volume of irradiated tissue in the patient.[9] The aluminum filter and collimator block most of the unwanted x-ray photons.

A lead glass vacuum tube prevents the escape of x-rays from anywhere but the "window," which allows the x-ray beam to exit the tube and directs the beam toward the aluminum disks, lead collimator, and the position-indicating device (PID).[9]

Importance of dental radiographs

The goal of exposing dental radiographs is to obtain diagnostic-quality images of the teeth and surrounding tissues. Acquiring knowledge of dental x-ray equipment and understanding how radiographs and radiation work will benefit the clinician and patient in avoiding distortion of images and unnecessary retakes.

Dental radiographs are an adjunctive diagnostic tool to assist in detecting oral pathological lesions, diseases, and conditions that cannot be identified clinically **(figure 3)**. Diagnostic dental radiographs help to find foreign objects such as a broken scaler tip, confirm or classify a suspected disease (periodontal disease and caries), and evaluate growth and development in orofacial structures.

The benefits of radiographs outweigh the financial health-care costs associated with exposure to dental radiation. Panoramic radiographic

FIGURE 3. An x-ray of a tooth with periapical abscesses on both roots

Wikimedia, Coronation Dental Specialty Group, Cc-by-3.0

findings can suggest diseases of significance, such as carotid artery calcifications, which can affect patients' longevity and quality of life.[10] Carotid artery calcifications are indicative of cardiovascular disease, which is the leading cause of death in the United States.[10]

Identifying and treating conditions early in their development may reduce unnecessary monetary expenses and discomfort and possibly even save a patient's life. Plaque, which consists of fatty substances, cholesterol, platelets, cellular waste products, and calcium, is deposited in the inner lining of the carotid and coronary arteries, resulting in more than 700,000 Americans suffering from strokes.[10,11]

Innovators of radiation

The modern understanding of ionizing radiation began in 1895 with Wilhelm Roentgen, a professor at the University of Wurzburg in Germany.[12-14] While conducting various experiments in applying currents to different vacuum tubes, he discovered that, despite covering one in a screen to block light, there seemed to be rays penetrating through to react with a barium solution on a screen he had placed nearby.[12-14] Roentgen captured the ability to excite electrons, point them through an object, and record that image on the surface in his vacuum tube **(figure 4)**. This groundbreaking discovery won him the Nobel Prize for physics in 1901.[12-14]

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Wilhelm Roentgen (March 27, 1845–February 10, 1923)

After several experiments, including taking the first radiograph of his wife's hand, Roentgen temporarily named the rays "x-rays" as a designation of something unknown, and the name has stuck.[12,13,15]

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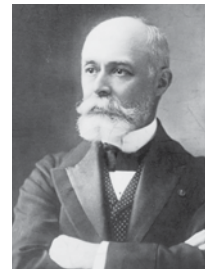
FIGURE 4. An early radiograph taken at a public lecture by Wilhelm Roentgen of Albert von Kölliker's left hand

The discovery of x-rays was followed in 1896 by Henri Becquerel's discovery that uranium salts gave off similar rays naturally.[13] Though he originally thought that phosphorescent uranium salts gave off the rays after prolonged exposure to the sun, he eventually abandoned this hypothesis.[13] Through further experimentation, including with nonphosphorescent uranium, he instead came to recognize that it was the material itself that gave off the rays.[13] In 1903 he shared the Nobel Prize for Physics with Pierre and Marie Curie.[14] This monumental discovery revolutionized the medical and dental professions' diagnostic capabilities and forever changed dentistry and medicine's practice.



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Henri Becquerel (December 15, 1852–August 25, 1908)

Marie Curie, a doctoral student of Henri Becquerel, is credited with creating the term "radioactivity."[14] She did more pioneering work with radioactive materials, including discovering additional radioactive elements: thorium, polonium, and radium.[14] She was awarded the Nobel Prize a second time for her discovery of radium and polonium.[13,14]

Curie continued working on the x-ray machine developed by Wilhelm Roentgen in 1895.[14,16] She used her newly discovered element, radium, as the gamma-ray source on x-ray machines, allowing for more accurate and stronger x-rays.[16] With German armies encroaching on the French capital, Curie gathered her entire supply of radium and stashed it in a remote bank vault. Early x-ray machines were enormous, so she designed a portable device that revolutionized medicine on and off the battlefield, combining a darkroom for developing images and an electric generator to power the process. These portable x-ray machines were called "petites Curies" **(figure 5)**.[16] Because of her work, military doctors were able to detect lodged metal pieces such as bullets and shrapnel without having

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Marie Curie (November 7, 1867–July 4, 1934)

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FIGURE 5. Marie Curie's mobile military hospital x-ray unit

to transport patients, which saved time and lives.

Dr. C. Edmond Kells, the "father of dental radiography," was a New Orleans dentist and pioneer in dentistry and medicine with numerous inventions and publications.[13,15,17] His most significant invention was the surgical aspirator for dental and medical surgery, which is still used today.[17] Dr. Kells was also one of the first dentists to hire a female dental assistant and the first to expose a dental radiograph in the United States.[13,18] Dr. Kells exposed his hands to numerous amounts of radiation daily for years, eventually leading to multiple cancers in his hand and costing him his fingers, hand, and later his arm.

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C. Edmond Kells (October 21, 1856–May 7, 1928)

Panoramic radiographs remain in widespread use for dental diagnosis and treatment planning. They provide a comprehensive view of teeth, gums, and surrounding structures. Their benefits include the ability to detect problems early, to see all teeth at once, and to plan dental treatment more accurately. Yrjo Veli Paatero, a dentist and the "father of panoramic radiography," experimented with the slit beam method of panoramic radiography for dental arches.[19] After World War II, in 1945, Dr. Paatero worked at the University of Helsinki's Institute of Dentistry, overseeing x-ray examinations and diagnostics. In 1949, he used the parabolographic technique by placing the film extraorally.[19] The first commercially manufactured panoramic radiography unit in the US, the Panorex, was introduced in 1959.[20]

Types of radiographs

Radiographs are one piece of the valuable armamentarium in diagnosing dental diseases and conditions. The most common methods of obtaining diagnostic radiographs are through bitewings, periapical, panoramic **(figure 6)**, and cone-beam computed tomography (CBCT) **(figure 7)**. Bitewing radiographs serve as a diagnostic tool for detecting interproximal caries and evaluating the condition of the periodontium.

Panoramic radiographs allow a broader view of the head, neck, and jaw. They provide a two-dimensional image of the teeth and maxillofacial skeletal structure to allow proper diagnosis and treatment planning for orthodontic evaluation, and evaluation of temporomandibular joints, third molar impaction, dental age estimation, bony defects, and lesions.[21]

Calcifications in the internal carotid artery have been detected by using panoramic dental imaging. Calcified atherosclerotic lesions at the carotid bifurcation can be seen in the lower corners of the panoramic radiograph adjacent to the cervical spine and hyoid bone.[10] Evidence of carotid calcifications in panoramic radiographs has been associated with stroke and/or ischemic heart diseases in 60- to 96-year-old individuals.[22,23] This type of dental imaging enhances the clinician's ability to educate patients about preventing heart attacks in conjunction with oral health education and diseases that affect oral and systemic health. Collaboration with the patient's medical provider will further assist in preventing heart attacks or stroke.

The cone-beam computed tomography scan[3] provides a 3D image of the entire oral cavity, nasopharynx, oropharynx, and a detailed view of the

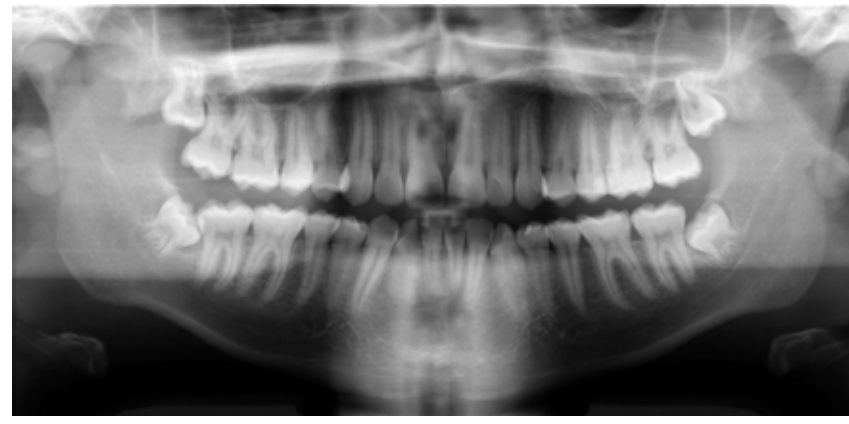

FIGURE 6. Dental panoramic radiograph Wikimedia, Coronation Dental Specialty Group, Cc-by-3.0

FIGURE 7. CBCT scan Wikimedia, Panda51, Cc-by-4.0

soft tissue and bone. Patients may be referred to a specialist for a carotid intima-media thickness (CIMT) test **(figure 8)**. A CIMT test detects an individual's risk for stroke, myocardial infarction, and death from coronary causes.[24]

Carotid artery disease occurs when fatty deposits (plaques) clog the blood vessels that deliver blood to the brain and head.[24] The blockage increases the risk of stroke, creating a medical emergency when the blood supply to the brain is interrupted or reduced.[24]

The CIMT test is a noninvasive medical procedure designed to assess the health of the carotid arteries, which are crucial blood vessels supplying the brain. It measures the thickness of the innermost two layers of the carotid artery walls, known as the intima and media, using high-frequency ultrasound. The primary purpose of the CIMT test is to evaluate a patient's risk of cardiovascular disease, particularly atherosclerosis, which is the accumulation of plaque in the arteries. A thicker intima-media layer is often indicative of early-stage atherosclerosis, which can lead to conditions such as stroke and heart disease. By providing valuable information about arterial health, the CIMT test enables health-care professionals to make informed decisions regarding the prevention and management of cardiovascular issues, thus potentially helping individuals reduce their risk of serious cardiac events.

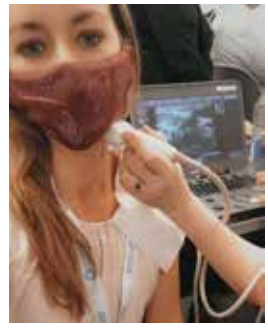

FIGURE 8. Author getting a CIMT measurement at a dental conference

Safety

Medical devices first came under comprehensive regulation with the passage of the 1938 Food, Drug, and Cosmetic Act.[25] In 1971, the Food and Drug Administration (FDA) also took on responsibility for consumer protection against unnecessary exposure to radiation-emitting devices for home and occupational use, a function that formerly had been in the Public Health Service.[25] In 1982, the organizational units at the FDA that regulated medical devices and radiation-emitting products merged to form the FDA Center for Devices and Radiological Health (CDRH).[25]

Extra precautions are needed to avoid unnecessary radiation exposure to the patient and the health-care professional. Radiographs should be prescribed only when the benefit outweighs the risk of biological damage **(figure 9)**.

ALARA

The practice of obtaining high-quality radiographs should comply with the ALARA (as low as reasonably achievable) protocol.[26-29] The x-ray unit should provide the highest possible quality radiography, exposing the patient to the smallest possible amount of radiation.

"As low as is reasonably achievable means making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken, the economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed or registered sources of radiation in the public interest."[27]

ALARA is a governmental approach to ensure safety when dealing with radiation while producing diagnostic radiographs. According to the CDC, even a small dose should be avoided if it has no direct benefit.[1,27-29]

Scatter radiation poses a risk for health-care professionals. The most at-risk individuals are radiology technicians and others who frequently administer x-rays. Similar to a stream of water hitting a surface and splashing off in all directions, scatter radiation is produced when a radiation beam hits an object. "While most of the radiation continues through the substance to create the radiograph, some of the rays come apart and bounce off the substance (whether that be tissue, bone, medical equipment, or even the walls of the room)."[28]

Monitoring radiation

A dosimeter is a device that measures an individual's exposure to ionizing radiation. This device is typically in the form of an external badge worn on the body. It is recommended to have the dosimeter frequently checked to determine an individual's level of exposure to ionizing radiation.

Radiation can spread out in different directions from a radiation beam when the beam interacts with a substance, such as body tissue.[29] The energy of scatter radiation is usually

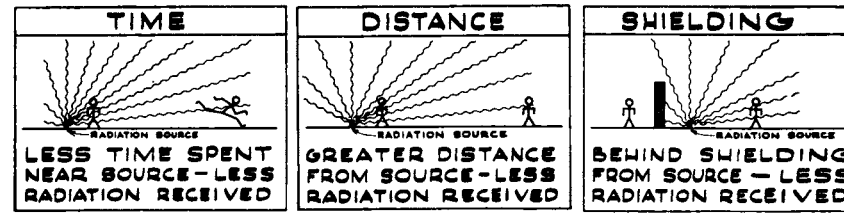

FIGURE 4.13.—Principles of Radiation Safety.

FIGURE 9. Principles of radiation safety Wikimedia, CC0, Richardson, Harry D., U.S. Atomic Energy Commission, Principles of Radiation Safety, extracted from Industrial radiography manual (1968)

much lower than that of the original radiation beam.[29] Less radiation may be scattered to the head, neck, and thyroid gland. "According to a study on dental practitioners and thyroid cancer, the risk of thyroid cancer was 13.1 times (95% CI 2.1–389) higher among female dentists and dental hygienists. It is believed that women are more likely to have thyroid cancer than men due to their hormones."[30]

The International Commission on Radiological Protection (ICRP) recommends limiting radiation exposure dose to 1 mSv for the public per year, and 20 mSv per year for occupational workers, averaged over defined periods of five years; ICRP also recommended that the dose limit should not exceed 50 mSv in any single year.[31]

Dental radiographs have many benefits, including the ability to detect bone loss and carious lesions, evaluate growth and development, and detect systemic issues through evaluations of the carotid artery to plan treatment more accurately. Radiographic exposure needs to be justified by the indications and the radiation risk evaluation to practice radiation safely to avoid scatter radiation.

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1. What type of electromagnetic radiation can be found in nature?
   - A. Radio waves
   - B. Visible light
   - C. Infrared waves
   - D. Ultraviolet rays

2. What term describes a form of energy that acts by removing electrons from atoms and molecules of materials, including air, water, and living tissue?
   - A. Ionizing radiation
   - B. Oxidizing radiation
   - C. Thermal radiation
   - D. Alpha radiation

3. What term describes the amount of ionizing radiation a person may be exposed to, supposedly without being harmed?
   - A. Minimum permissible dose
   - B. Roentgen equivalent man
   - C. Maximum permissible dose
   - D. Sievert dose

4. The international unit of x-radiation or gamma radiation is equal to the amount of radiation produced in how many cubic centimeters of dry air at 0°C?
   - A. 10
   - B. 3
   - C. 5
   - D. 1

5. What measurement is defined as the amount of radiation roughly equivalent in biological effectiveness to 100 rads of gamma radiation?
   - A. Sievert
   - B.vRoentgen
   - C. Becquerel
   - D. Curie

6. How many Americans have suffered strokes as the result of fatty substances, cholesterol, platelets, cellular waste products, and calcium being deposited in the inner lining of the carotid and coronary arteries?
   - A. 600,000
   - B. 700,000
   - C. 800,000
   - D. 900,000

7. In what year were x-rays discovered?
   - A. 1873
   - B. 1868
   - C. 1885
   - D. 1895

8. Roentgen's groundbreaking discovery of the ability to excite electrons, point them through an object, and record the image won him the Nobel Prize in which category?
   - A. Literature
   - B. Chemistry
   - C. Physics
   - D. Medicine

9. What is the name of the test used to measure and diagnose the extent of atherosclerotic vascular disease?
   - A. CDU (carotid duplex ultrasonography)
   - B. CIMT (carotid intima-media thickness)
   - C. CTA (computed tomography angiography)
   - D. MRA (magnetic resonance angiography)

10. What three radioactive elements did Marie Curie discover?
   - A. Radium, carbon, argon
   - B. Polonium, aluminum, beryllium
   - C. Thorium, polonium, radium
   - D. Copper, thorium, vanadium

11. In 1895, which newly discovered element allowed for more accurate and stronger x-rays?
   - A. Radium
   - B. Thorium
   - C. Argon
   - D. Titanium

12. Who developed mobile x-ray machines for World War I battlefields?
   - A. Henri Becquerel
   - B. Pierre Curie
   - C. Edmond Kells
   - D. Marie Curie

13. Who is known as the "father of dental radiography"?
   - A. Pierre Curie
   - B. Edmond Kells
   - C. Antonie Philips van Leeuwenhoek
   - D. Yrjo Veli Paatero

14. Who is known as one of the first dentists to hire a female dental assistant and the first to expose a dental radiograph in the United States?
   - A. Edmond Kells
   - B. Friedrich Otto Walkhoff
   - C. Wilhelm Roentgen
   - D. Henri Becquerel

15. Who is known as the "father of panoramic radiography"?
   - A. Pierre Fauchard
   - B. Edmond Kells
   - C. Antonie Philips van Leeuwenhoek
   - D. Yrjo Veli Paatero

16. After the end of World War II in 1945, Yrjo Veli Paatero worked at which university overseeing x-ray examinations and diagnostics?
   - A. Nordic Institute of Dental Education
   - B. University of Helsinki's Institute of Dentistry
   - C. Newcastle University School of Dental Sciences
   - D. Edinburgh Dental Institute

17. What is the name of the technique Dr. Paatero used by placing the film extraorally?
   - A. Bisecting angle technique
   - B. Schenectady technique
   - C. Parabolographic technique
   - D. Postero-anterior technique

18. What was the name of the first commercially manufactured panoramic radiography unit in the United States?
   - A. Promax
   - B. Pax
   - C. VistaPano
   - D. Panorex

19. The anode is a piece of tungsten that is heated by an electrical current. The cathode is a piece of tungsten that is cooled by an electrical current.
   - A. Both statements are true.
   - B. Both statements are false.
   - C. The first statement is true; the second statement is false.
   - D. The first statement is false; the second statement is true.

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20. What two components does the cathode include with the purpose of supplying electrons necessary to generate x-rays?

A. Anode and neutrons
B. Tungsten target and copper stem
C. Protons and aluminum filter
D. Copper stem and barium target

21. What is the wire filament in the tungsten target made of?

A. Copper
B. Rubidium
C. Molybdenum
D. Aluminum

22. What is the term for the metallic barrier with an aperture in the middle used to reduce the x-ray beam's size and shape, thereby reducing the volume of irradiated tissue in the patient?

A. Collimator
B. Lead glass vacuum tube
C. Aluminum filter
D. Tungsten target

23. What two components of the lead glass vacuum tube block the majority of the unwanted x-ray photons?

A. Cathode and PID
B. Copper stem and collimator
C. Aluminum filter and tungsten wire
D. Aluminum filter and collimator

24. What device that measures an individual's exposure to ionizing radiation is worn on the body?

A. Geiger-Mueller (GM) detector
B. Portal monitor
C. Dosimeter
D. Scintillator

25. What type of imaging shows the entire oral cavity, nasopharynx, oropharynx, and a detailed view of the soft tissue and bone?

A. Panoramic radiograph
B. Cone-beam computed tomography
C. Cephalometric radiograph
D. Magnetic resonance imaging

26. In what year did the Food and Drug Administration take responsibility for consumer protection against unnecessary exposure to radiation-emitting devices for home and occupational use?

A. 1971
B. 1981
C. 1978
D. 2001

27. In what year did the organizational units at the FDA that regulated medical devices and radiation-emitting products merge to form the Center for Devices and Radiological Health?

A. 1979
B. 1982
C. 1953
D. 1993

28. An x-ray unit should provide the highest possible quality radiography, exposing the patient to the smallest possible amount of radiation. What is the term used to describe this type of protocol?

A. ALI
B. ANSI
C. BEIR
D. ALARA

29. Women are ___ times more likely to have thyroid cancer than men due to their hormones.

A. 3
B. 6
C. 1
D. 7

30. Which organization recommends that the radiation dose limit not exceed 50 mSv in any single year?

A. Center for Devices and Radiological Health
B. National Council on Radiation Protection and Measurements
C. Federal Office for Radiation Protection
D. International Commission on Radiological Protection

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EXPIRES: **APRIL 2027**

Are you curie-ous about radiation?

NAME: TITLE: SPECIALTY:

ADDRESS: EMAIL: AGD MEMBER ID (IF APPLIES):

CITY: STATE: ZIP: COUNTRY:

TELEPHONE (PRIMARY): TELEPHONE (OFFICE):

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EDUCATIONAL OBJECTIVES

1. Define radiation and explain how radiation exposure is measured.
2. Identify x-ray components and their functions.
3. Identify key innovators in the discovery of radiation.
4. Define the ALARA philosophy.

COURSE EVALUATION

1. Were the individual course objectives met?
   Objective #1: Yes No Objective #3: Yes No
   Objective #2: Yes No Objective #4: Yes No

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

2. To what extent were the course objectives accomplished overall? 5 4 3 2 1 0
3. Please rate your personal mastery of the course objectives. 5 4 3 2 1 0
4. How would you rate the objectives and educational methods? 5 4 3 2 1 0
5. How do you rate the author's grasp of the topic? 5 4 3 2 1 0
6. Please rate the author's effectiveness. 5 4 3 2 1 0
7. Was the overall administration of the course effective? 5 4 3 2 1 0
8. Please rate the usefulness and clinical applicability of this course. 5 4 3 2 1 0
9. Please rate the usefulness of the references. 5 4 3 2 1 0
10. Do you feel that the references were adequate? Yes No
11. Would you take a similar course on a different topic? Yes No
12. If any of the continuing education questions were unclear or ambiguous, please list them.

    _____

13. Was there any subject matter you found confusing? Please describe.

    _____

14. How long did it take you to complete this course?

    _____

15. What additional dental continuing education topics would you like to see?

    _____

    _____

Mail/fax completed answer sheet to:

Endeavor Business Media
Attn: Dental Division; 7666 E. 61st St. Suite 230, Tulsa, OK 74133
Fax: (918) 831-9804

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4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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EXAM INSTRUCTIONS. All questions have only one answer. If mailed or faxed, grading of this examination is done manually. Participants will receive confirmation of passing by receipt of a Verification of Participation form. The form will be mailed within two weeks after receipt of an examination.

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