

### Islamic Contribution to Math and Science

There is a lack of acknowledgment of contributions made by historic Islamic scholars' in many fields including science and math, despite four centuries of rich contributions during the 9<sup>th</sup> to 13<sup>th</sup> centuries. In fact, during this Islamic golden age, concepts instrumental in the furtherment of science (as we practice it today) stem from concepts of accuracy, precision, experimentation, and peer review. These ideas were refined and passed on from the scientist during this period. In Islamic centers multicultural scholars were brought together solely for the pursuit of knowledge. Ancient texts were translated into Arabic and ideas were further developed through experimentation while great attention was paid to precision and accuracy.

The Science in the Golden Age documentary series, by Al-Jazeera, highlights the contributions of some of the greatest thinkers of all time like Al-Kindi, Al-Tusi, Al-Biruni, the Banu Musa brothers, Jabir Ibn Hayyan, etc. These names are unknown in the West and their fundamental contributions have been brushed over. There are six videos in this series covering **astronomy, chemistry, biology, engineering, optics, and algebra**. Each episode stands alone and can be viewed independently.

Each episode has:

- a worksheet for students with video link
- teachers guide with answers for all questions
- curriculum expectations for Ontario curriculum
- a reference list

Episode	Title	Curriculum Links	Grade
1	<b>Astronomy the science of the stars</b>	Earth and Space Astronomy & Planetary Science	9 Science 12 Earth & Space Science
2	<b>Al-Khwarizmi: The Father of Algebra</b>	Kinematics, Forces Geometry, Algebra	11 Physics 9 -10 Math
3	<b>Optics: The True Nature of Light</b>	Optics	10 Science
4	<b>Pioneers of Engineering: Al-Jazari and the Banu Musa</b>	Kinematics, Forces, Energy & society Energy and Momentum	11 Physics 12 Physics
5	<b>Chemistry</b>	Acid Base Chemistry, Activity Series, Reactivity Distillation, Saponification	11 Chemistry 12 Chemistry
6	<b>Al-Razi, Ibn Sina and the Canon of Medicine</b>	Human Systems Animals, Genetics, Plants Genetics, Molecular Biology	9 Science 11 Biology 12 Biology

**Science in a Golden Age-Astronomy: The Science of the Stars**

<https://www.aljazeera.com/program/science-in-a-golden-age/2015/10/13/astronomy-the-science-of-the-stars>

(25:20)

**Gr 9 Science-Astronomy and Gr12 Earth and Space Science**

**Teachers Guide: Questions and Answers**

Watch the video and answer the questions below.

- 1) When did scholars from the Islamic world consolidate, refine and contribute to the body of astronomical information?  
**between the 9<sup>th</sup> and 14<sup>th</sup> century**
- 2) Why were the scholars of the Islamic world so interested in astronomy?
  - **navigation**
  - **measurement of the time**
  - **prediction of religious festivals (Islamic calendar is lunar)**
- 3) How do people find their way around a desert so accurately? **Using the sun's location during the day and using the stars at night**
- 4) How much shorter is the lunar calendar to the Gregorian calendar? **It is shorter by 11 days.**
- 5) In the 9<sup>th</sup> century, why were new astrological charts started? **To improve on the Greek astrological charts that already existed by making them more accurate.**
- 6) What were these new charts called? **The verified tables**
- 7) Which ancient Greek compiled over 8000 coordinates around the world? **Ptolemy**
- 8) In the 9<sup>th</sup> century, who was commissioned to make a new map of the world? **Islamic scholars were commissioned by Al'Mamoon**
- 9) Why do the ancient Arabic maps not look familiar to us? **All Arabic maps from that period are southward facing, in other words they are upside down.**
- 10) What is so significant about these maps? **They were very accurate and precise and were the basis of the maps used in Europe to navigate the world.**
- 11) What does an astrolabe have to do with maps? **Astrolabe was used to collect the data to make accurate and precise maps.**

**Astronomy**

- 12) Where did astrolabes originate from? **Greece**
- 13) What could Islamic astrolabes be used for?
- **to keep time**
  - **to find prayer times**
  - **to navigate**
  - **to measure the heights of things like buildings**
  - **to measure distances**
- 14) What legacy was left behind from the way astronomy was practiced in the Golden age of science? **Astronomy scholars would come together to work and collaborate, from all over the world, and they still do that today.**
- 15) What is the function of the dish on a telescope, like the Lovell Radio Telescope? **It collects faint radio signals from space.**
- 16) What images does a radio telescope pick up? **The stuff between the stars**
- 17) How do modern day scientists get sharp pictures of space? **They collect data from telescopes around the world and pool the information together.**
- 18) Where did the first groups of astronomers work together? **Baghdad**
- 19) Where was the Maragheh observatory? **Built in 1259 in Persia.**
- 20) Who is one of the greatest astronomers? **Al-Tusi**
- 21) What did Al-Tusi promise the Mongols if they spared his life and was allowed him to continue his astronomy work? **Al-Tusi promised to provide astrological charts in exchange for life and allowing him to continue his work simultaneously he convinced the Mongols to build him a new observatory.**
- 22) What made work at the Maraghen observatory so important? **The mathematical tricks they developed were used in astronomy for centuries.**
- 23) What did the Greeks believe about the solar system? **They believed that the earth was the centre and the sun orbited around it.**
- 24) What was so important about the diagram called the Tusi couple? **The Tusi couple simplified earth's orbit calculations.**

25) Who used Al-Tusi's work in Europe to prove that the earth revolved around the sun?

**Copernicus**

26) Why was astronomical work so important in the Islamic world?

- **to keep accurate time for prayers**
- **to know the direction to Mecca (this is the direction of prayers)**
- **to know the dates of religious festivals according to the lunar calendar**

27) To determine the direction to pray towards Mecca earlier Islamic scholar had to develop...  
**spherical geometry.**

28) The Persian astronomer, Al-Biruni was able to measure the circumference of the earth by... **measuring the angle of the sun's dip from the horizontal to the distance horizon from on top of a mountain, then he used geometry to do his calculations.**

29) Astronomical and scientific history, according to the West, started with the Greeks and moved on to the Renaissance period as if the nothing occurred during the 9<sup>th</sup> to the 13<sup>th</sup> century. Is this portrayal of history accurate? Why or why not? **No during this time Islamic society gathered and built on knowledge which was then used as the**

## Astronomy

### Gr 12 Earth and Space Science: Curriculum Expectations

#### Big Ideas

- **Astronomy (Science of the Universe)** The development of more sophisticated technologies has enabled us to achieve a deeper, more thorough understanding of the origin and evolution of the universe. Scientific theories about the universe are refined and altered as new evidence is discovered.
- **Planetary Science (Science of the Solar System)** Space exploration and the technologies that have been developed to facilitate it have had positive and negative effects on society, the economy, and the environment. Space exploration presents many hazards. Interactions among bodies within the solar system have an impact on the existence of life

**Gr 9 Science: Astronomy Curriculum Expectations**

**Big Ideas**

- Different types of celestial objects in the solar system and universe have distinct properties that can be investigated and quantified.
- People use observational evidence of the properties of the solar system and the universe to develop theories to explain their formation and evolution.

**Overall Expectations**

D2. investigate the characteristics and properties of a variety of celestial objects visible from Earth in the night sky;

D3. demonstrate an understanding of the major scientific theories about the structure, formation, and evolution of the universe and its components and of the evidence that supports these theories.

**Relating Science to Technology, Society, and the Environment**

D1.1 assess, on the basis of research, and report on the contributions of Canadian governments, organizations, businesses, and/or individuals to space technology, research, and/or exploration (e.g., as part of the International Space Station mission; in the fields of telecommunications and satellite technology) [IP, PR, AI, C]

**Developing Skills of Investigation and Communication**

D2.1 use appropriate terminology related to the study of the universe, including, but not limited to: celestial objects, orbital radius, retrograde motion, and satellite [C]

**Understanding Big Concepts**

D3.2 describe observational and theoretical evidence relating to the formation of the solar system (e.g., evidence that supports the theory that the solar system was formed from a contracting, spinning disc of dust and gas)

D3.3 describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years)

D3.6 describe various reasons that humankind has had for studying space (e.g., to develop calendars for agricultural purposes, to forecast weather, for celestial navigation, for religious inspiration) and the conceptions of the universe held by various cultures and civilizations (e.g., Aboriginal peoples; ancient Greek, Mayan civilizations)

Gr 9 & 10 Math: Algebra & Geometry & Gr 11 Physics: Kinematics

**Al-Khwarizmi: The  
Father of Algebra**

[https://www.aljazeera.com/  
program/science-in-a-  
golden-age/2015/10/20/al-  
khwarizmi-the-father-of-  
algebra](https://www.aljazeera.com/program/science-in-a-golden-age/2015/10/20/al-khwarizmi-the-father-of-algebra) (25:03)

**Teachers Guide Questions and Answers**

- 1) When did scholars from the Islamic world first apply the principles of mathematics to science? **between the 9<sup>th</sup> and 14<sup>th</sup> century**
- 2) How does math play a role in the science of flying?
  - **math helps us understand the science of the flying**
  - **lift and velocity are directly related**

**Algebra Kinematics**

- 3) Who wrote the *Compendious Book of Calculations by Completion and Balancing*? **Al-Khwarizmi**
- 4) Even though Al-Khwarizmi was not the first to use quadratic equations, he is known as the father of algebra because... **he provided the algorithm or the method to solve quadratic equations.**
- 5) What makes Al-Khwarizmi's mathematics textbook so unique? **The whole book contains no equations, he wrote the whole book in words only.**
- 6) Andy Green holds a world record for... **travelling faster than the speed of sound**
- 7) How fast can Bloodhound travel? **1600 km/hr or 1000 miles/hr or 40% faster than the speed of sound**
- 8) By how much will drag effect the Bloodhound? **Drag is a square law therefore there will be a lot of drag on the car --4x times**
- 9) How is power effected? **8x the power is needed**
- 10) Where is the renown center of learning in the world during medieval times? **Baghdad**
- 11) What was the name of the greatest center of learning during the medieval times? **The House of Wisdom**
- 12) Where did the scholars from the House of Wisdom come from? **All sorts of religions, Islamic, Christians, Jewish, Hindu and Zoroastrians**
- 13) What books were translated in the House of Wisdom?
  - **Greeks mostly**
  - **Sanskrit (Indian)**

- **Persian**

14) What is significance of all the translated works? **Without all the translations all the knowledge would not have accumulated together. This is the key as it was the driving force behind mathematics and science knowledge than. And this knowledge is the base of knowledge used to build today's technologies.**

15) Where did the inspiration for geometry come from? **Greek, Roman and Byzantine**

16) How did geometry help, the Islamic scholars, improve on the Greeks maps? **They created more accurate maps**

17) In what other area of study did geometrical knowledge help the scholars? **Astronomy as calculations were used to describe the movement of moon, planets, and stars.**

18) Where did the numerical system we use today come from? **India was the first to use a decimal system, the Arabs brought it to the rest of the world.**

19) Which Italian mathematician promoted using Hindu-Arabic number system? **Fibonacci**

20) What excuse was used to ban the Hindu-Arabic number system in Florence, in 1299? **They said were easy to falsify**

21) When was the Hindu-Arabic number system finally adopted in Europe? **15<sup>th</sup> century, that is 600 years after they were first introduced in the Islamic world.**

22) Encryption has its origins in what century? **9<sup>th</sup> century**

23) Al-Kindi, studies frequency analysis, which is the study of how many times a letter appears to determine what letter it is, this technique is used in... **Code breaking**

24) What fields did the advancements of mathematics, during the 9<sup>th</sup> to 13<sup>th</sup> century, help advance during that time?

- **Astronomy,**
- **Medicine,**
- **Optics,**
- **Engineering,**
- **Chemistry**

Gr 9 & 10 Math: Curriculum Expectations

**Big Ideas**

- make connections among mathematical concepts and procedures, and relate mathematical ideas to situations or phenomena drawn from other contexts (e.g., other curriculum areas, daily life, current events, art and culture, sports);

Gr 11 Physics: Curriculum Expectations

**Relating Science to Technology, Society, and the Environment**

A2.2 describe the contributions of scientists, including Canadians, to the fields under study

**Kinematics**

B2.1 use appropriate terminology related to kinematics, including, but not limited to: time, distance, position, displacement, speed, velocity, and acceleration [C]

**Forces**

C3.1 distinguish between, and provide examples of, different forces (e.g., friction, gravity, normal force), and describe the effect of each type of force on the velocity of an object

Gr 10 Science: Optics

Science in a Golden Age-  
Optics: The True Nature of  
Light

<https://www.aljazeera.com/programs/science-in-a-golden-age/2015/10/6/optics-the-true-nature-of-light> (24:35)

Teachers Guide Questions and Answers

- 1) What is a synchrotron? **A giant particle accelerator that produces high energy lights for experiments**
- 2) What can it be used for? - **study the structure of matter in detail,**

- **learn more about cancer growth**
- **analyze cracks in concert to see why bridges fail**
- **study pollution in soil**

- 3) How was science advanced 1000 years ago? **Leading scholars from around the world were brought together in the Islamic world.**
- 4) How did the coming together of leading scholars forward our thinking in optics? **It allowed many great minds to come together and work on problems together thereby setting the basics for the way we think about light today.**
- 5) What does a microtron do? **It produces electrons and accelerates them.**
- 6) What is the purpose of the booster? **It increases the speed of electrons, so they are almost travelling the speed of light.**
- 7) Once the electrons reach the speed of light where do they go? **Storage ring**
- 8) How do electrons lose synchrotron light? **They are moved around by magnets which slows them down and caused them to lose light, this is the synchrotron light.**
- 9) What experiment is Shadid working on? **Using infrared light to see the effects of drugs on skin.**
- 10) How does she use infrared spectrum to study skin? **She looks for the changes in the infrared spectrum.**
- 11) How will the synchrotron light benefit her study? **Better resolution therefore clearer pictures.**
- 12) Who laid the foundations of our understanding of light? **The scholars of the medieval Islamic world**
- 13) When did Isaac Newton study in Cambridge? **17<sup>th</sup> century**
- 14) Ibn Haytham was considered the father of optics, and was born when? **10<sup>th</sup> century**
- 15) What is one possible reason that Ibn Haytham went to Cairo? **To build a dam to stop the Nile from flooding.**
- 16) What happened when Ibn Haytham was not able to stop the Nile from flooding? **He was thrown into an asylum, after faking madness.**
- 17) Kitab al-Manazir is also known as... **the book of optics**
- 18) What is Ibn Haytham's most famous experiment? **Camera obscura**
- 19) What type of camera is it? **Giant pinhole camera**

- 20) What is the significance of the camera obscura? **It was used to prove that light travels in a straight line and also used to explain how the eye works.**
- 21) How can you get the image focused? **Make the hole smaller.**
- 22) Why is the image upside down? **Because light travels in straight lines**
- 23) Why is Ibn Haytham's work so valued? **He was able to prove that light travels in straight lines mathematically.**
- 24) How did the ancient Greeks explain how the eye works? **We see by shining light out of our eyes on to the objects.**
- 25) How did Ibn Haytham explain how the eye works? **Light enters our eyes by reflecting off objects or from luminous objects.**
- 26) What makes Ibn Haytham's work so important to science? **He used experiments and math to prove theories.**
- 27) What is a photovoltaic cell? **A cell that collects energy**
- 28) What applications are there for transmitting energy through light? **To transmit solar power anywhere on the earth energy is needed,**
- 29) What kind of light does the internet use to transmit data? **Infrared light**
- 30) Why is a light fountain an optical illusion? **It looks like the light is moving with the water, in fact the light is travelling in straight lines and reflecting off the water droplets into our eyes.**
- 31) What does Snell and Ibn Sahl have in common? **Both Snell and Ibn Sahl describe Law of Refraction, and Ibn Sahl did it centuries earlier than Snell**
- 32) How did Ibn Sahl improve on the ancient Greeks explanation of refraction? **The ancient Greeks correctly said the ratio was a constant number, but they described the ratio between the arcs in the circle. Ibn Sahl described the constant number as the ratio between the accords or straight lines.**
- 33) Who do you think should be given the credit for law of refraction? **Ibn Sahl because he discovered it 650 years before Snell or Descartes.**
- How did Ibn Mu'adh estimate the height of the atmosphere? **He used geometry.**

**Gr 10 Science Optics Curriculum Expectations**

**Optics**

**Big Ideas**

- Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses.
- Society has benefited from the development of a range of optical devices and technologies.

**Overall Expectations**

E1. evaluate the effectiveness of technological devices and procedures designed to make use of light, and assess their social benefits

**Relating Science to Technology, Society and Environment**

E1.1 analyse a technological device or procedure related to human perception of light (e.g., eyeglasses, contact lenses, infrared or low light vision sensors, laser surgery), and evaluate its effectiveness [AI, C]

E1.2 analyse a technological device that uses the properties of light (e.g., microscope, retroreflector, solar oven, camera), and explain how it has enhanced society [AI, C]

**Pioneers of Engineering: Al-Jazari and the Banu Musa**

<https://www.aljazeera.com/progr am/science-in-a-golden-age/2015/10/27/pioneers-of-engineering-al-jazari-and-the-banu-musa> (20:09)

**Teachers Guide Questions and Answers**

1) What is Moley robotic kitchen capable of doing?

**The robotic arms replicate a cook's arm and is more consistent than a cook, but all the ingredients must be in exact spots.**

2) What is the Kitab al-Hiyal? **The book of tricks**

**contains a range of inventions & contraptions to make life easier.**

3) When was Kitab al-Hiyal written? **The 9<sup>th</sup> century**

4) Who wrote Kitab al-Hiyal? **3 Banu Musa brothers**

5) Give an example of the type of things in the Kitab al-Hiyal.

- **Water dispensing tool,**
- **self correcting lamp,**
- **a flute the plays itself,**
- **lots of tools**
- **contraptions and devices for daily life**

6) Where was the inspiration taken for the Kitab al-Hiyal? **Ancient Greeks, Chinese, Persians, and Indian idea**

7) What disciplines did the Banu Musa brothers study?

- **Math**
- **Engineering**
- **Astronomy**

8) Where did the brothers study? **The house of wisdom in Baghdad**

9) What was special about the house of wisdom? **Great texts from around the world were studied and translated**

10) What was special about the Book of Tricks? **They incorporated many forward-thinking processes that were not adapted until many centuries later like crank shafts and pressure differences in air and water to make things appear to move on their own.**

11) The Banu Musa brothers used ideas from Archimedes but... **put them together in new ways, rethinking the ideas.**

12) What is the most complicated device that the brothers put together? **A drive wheel, operated by water, turning a rotating drum with a cam that lift little arms that seal or unseal flute holes. The rotating drum can be changed to make different tunes.—A self playing instrument.**

13) When was a music box invented? **16-17<sup>th</sup> century inventions**

14) What played a key role in many medieval engineering projects? **Water**

15) Who did the Islamic world, in the 9<sup>th</sup> century, inherit their knowledge of irrigation and water supply from? **Greeks, Roman, Egyptians**

16) New techniques were used to capture, store, and raise water such as... **hydraulic pumps**

- 17) When was Al-Jazari, a prolific engineer, born? **In the 12<sup>th</sup> century**
- 18) Where was the Artuqid Palace? **Turkey**
- 19) Why were Al-Jazari's devices important? **reservoirs, dams, and water storage were important to the development of societies.**
- 20) What is noria? **Water wheel**
- 21) Describe the sophisticated water wheel that Al-Jazari made? **Used a valve that sucks water up with a double pumping water wheel which also used gears and pistons.**
- 22) What device converts the rotating motions of a water wheel into linear motion **Crank slider**
- 23) What text did Al-Jazari write? **The complete book of knowledge and work**
- 24) Why are clocks so important in Islam? **Prayers times are very accurate therefore clocks must be precise**
- 25) Abbas Ibn Firnas was very accomplished in glassmaking and magnifying lens and was also know for? **Making himself fly with wood and bird feathers**

## Curriculum Expectations Grade 11 Physics

### Big Ideas

- Motion can be described using mathematical relationships.
- Many technologies that apply concepts related to kinematics have societal and environmental implications.
- Forces can change the motion of an object.
- Energy can be transformed from one type to another

### Career Exploration

A2.2 describe the contributions of scientists, including Canadians, to the fields under study

### Kinematics

B1.1 analyse, on the basis of research, a technology that applies concepts related to kinematics (e.g., devices used to measure speed in sports; rocket accelerators; motion-detecting sensors for security systems; speedometers in automobiles) [IP, PR, AI, C]

### Forces

C2.1 use appropriate terminology related to forces, including, but not limited to: mass, time, speed, velocity, acceleration, friction, gravity, normal force, and free-body diagrams [C]

### Energy and Society

D 2.1 use appropriate terminology related to energy transformations, including, but not limited to: mechanical energy, gravitational potential energy, kinetic energy, work, power, fission, fusion, heat, heat capacity, temperature, and latent heat [C]

## Curriculum Expectations Grade 12 Physics

### Big Ideas

- Forces affect motion in predictable and quantifiable ways. Forces acting on an object will determine the motion of that object. Many technologies that utilize the principles of dynamics have societal and environmental implications
- New theories can change scientific thought and lead to the development of new technologies.

### Career Exploration

A2.1 identify and describe a variety of careers related to the fields of science under study and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including, to the fields under study

### Energy and Momentum

C2.1 use appropriate terminology related to energy and momentum, including, but not limited to: work, work–energy theorem, kinetic energy, gravitational potential energy, elastic potential energy, thermal energy, impulse, change in momentum–impulse theorem, elastic collision, and inelastic collision [C]

Gr 11 & 12 Chemistry

Science in a Golden Age -  
Chemistry: The Search for  
the Philosopher's Stone

<https://www.aljazeera.com/program/science-in-a-golden-age/2015/11/3/chemistry-the-search-for-the-philosophers-stone> (25:04)

Teachers Guide Questions and Answers

- 1) Explain Fractional Distillation? **Fractional Distillation is used to separate out crude oil into many different substances as vapours separate in the cooling tower which all have different boiling points.**
- 2) What is an alembic? - **used as a distillation tool**
- 3) Who is Al-Razi? **He was one of the first to use distillation to make alcohol for medical uses.**
- 4) Who is Jabir Ibn Hayyan? **He was regarded as the first scientist of the golden age**
- 5) Many of Jabir Ibn Hayyan chemical procedures are in use today such as ... **calcination, precipitation or distillation.**
- 6) Where did Jabir Ibn Hayyan grow up? **Iraq**
- 7) Why would another scientist write under Jabir Ibn Hayyan's name? **because he was very well respected and held in high regard therefore writing under his name would make their work received better.**
- 8) What was his contribution to the field of chemistry besides his equipment? **He used an experimental based approach to chemistry. He used the scientific method.**
- 9) Why was this different than the ancient Greek's approach? **The Greeks used pure philosophical thinking.**
- 10) What did glass blowing have to do with chemistry at the time? **They did not have any chemical equipment at the time so they designed their own and had it made.**
- 11) What does the Arabic word alchimia mean? **Chemistry or Alchemy**
- 12) What is the difference between alchemy and chemistry? **Chemistry is a rigorous science, but alchemy is associated with magic and superstition. Alchemy's goal was to turn metals into gold.**
- 13) What lead Jabir Ibn Hayyan to work with acids? **He was trying to dissolve metals.**
- 14) Why is it difficult to dissolve gold? **It is relatively unreactive.**
- 15) Kingly water or aqua regia can dissolve gold, what is it made of? **Nitric acid (HNO<sub>3</sub>) and hydrochloric acid (HCl)**
- 16) Why was much of the chemistry driven by Islam? **Islam has a high standard of cleanliness which drove the early chemists to produce soap.**
- 17) Acid base chemistry traces its roots to.. **Jabir Ibn Hayyan**
- 18) What does the Arabic word al-khali mean? **Alkanline –The ashes of salt water, which is the origin of bases**

- 19) What is saponification? **The chemical process of making soap.**
- 20) When was soap making industrialized? **12<sup>th</sup> century**
- 21) What is the process of saponification or soap making? **An oil is mixed with an alkaline, then dried.**
- 22) Why are the Islamic scholars regarded as the first scientists? **Because of their obsession of accuracy and precision**
- 23) Why is categorizing substances useful? **It allows us to understand things better.**
- 24) How did Jabir Ibn Hayyan revolutionize science? **He categorized substances based on how they behaved in experiments. This was never done before.**
- 25) By describing how different metal reacted with sulphur he created an... **activity series**
- 26) Did Islamic scholars of 9<sup>th</sup> to 14<sup>th</sup> centuries like Jabir Ibn Hayyan, Al-Kindi and Al-Razi contribute to the field of chemistry? **Yes**
- **they lay the foundation of the scientific method**
  - **they development specialized equipment still used today**
  - **they developed chemical processes like distillation and saponification still used today**
  - **they categorized chemicals based on reactivity with other chemicals**
  - **they laid the foundation for acid base chemistry**
  - **they used accurate and precise instrumentation and observation**
  - **they used experiments to describe things**

### Gr 11 Chemistry Curriculum Expectations

#### Big Ideas

- Chemical Reactions Chemicals react in predictable ways. Chemical reactions and their applications have significant implications for society and the environment.
- Properties of solutions can be described qualitatively and quantitatively and can be predicted.

#### Career Exploration

A2.2 describe the contributions of scientists, including Canadians, to the fields under study

#### Matter, Chemical Trends and Chemical Bonding

B2.1 use appropriate terminology related to chemical trends and chemical bonding, including, but not limited to: atomic radius, effective nuclear charge, electronegativity, ionization energy, and electron affinity [C]

#### Chemical Reactions

C2.1 use appropriate terminology related to chemical reactions, including, but not limited to: neutralization, precipitate, acidic, and basic [C]

## Science in a Golden Age: Answers to Worksheets

C3.3 explain the chemical reactions that result in the formation of acids and bases from metal oxides and non-metal oxides (e.g., calcium oxide reacts with water to produce a basic solution; carbon dioxide reacts with water to produce an acidic solution)

### Quantities Chemical Reactions

D2.1 use appropriate terminology related to quantities in chemical reactions, including, but not limited to: stoichiometry, percentage yield, limiting reagent, mole, and atomic mass [C]

### Solutions and Solubility

E2.1 use appropriate terminology related to aqueous solutions and solubility, including, but not limited to: concentration, solubility, precipitate, ionization, dissociation, pH, dilute, solute, and solvent [C]

## Gr 12 Chemistry Curriculum Expectations

### Career Exploration

A2.2 describe the contributions of scientists, including Canadians to the fields under study

### Organic Chemistry

B3.2 describe the similarities and differences in physical properties (e.g., solubility in different solvents, odour, melting point, boiling point) within each class of organic compounds

B3.3 explain the chemical changes that occur during various types of organic chemical reactions, including substitution, addition, elimination, oxidation, esterification, and hydrolysis

## Gr 12 College Chemistry Curriculum Expectations

### Overall Expectations

D2. investigate the characteristics and properties of a variety of celestial objects visible from Earth in the night sky;

D3. demonstrate an understanding of the major scientific theories about the structure, formation, and evolution of the universe and its components and of the evidence that supports these theories.

### Matter and Qualitative Analysis

B3.3 explain basic procedures used in qualitative analysis of elements and compounds, including flame tests, precipitation reactions, and the observation of emission spectra

### Organic Chemistry

C3.5 explain how the physical properties of a substance affect the processes used to separate organic chemical substances (e.g., distillation of crude oil, distillation of alcohols)

Gr 10 Science: Biology & Gr 11 & 12 Biology

**Science in a Golden Age  
– Al-Razi, Ibn Sina and  
the Canon of Medicine**

<https://www.aljazeera.com/program/science-in-a-golden-age/2015/11/9/al-razi-ibn-sina-and-the-canon-of-medicine> (25:24)

**Teachers Guide Questions and Answers**

- 1) Modern science is built on a lot of research that was accumulate when? **Between the 9<sup>th</sup> to 14<sup>th</sup> century a Golden Age in Science**
- 2) What did Islamic scholars contribute during this time period? **They accumulated body of knowledge that was used for many hundreds of years around the world.**
- 3) When was medicine first treated as a true science? **During the Golden Age of Science-9<sup>th</sup> to 14<sup>th</sup> century**
- 4) How was medicine treated as a true science during the Golden Age of Science? **It was the first-time empirical evidence and repeatable procedures were emphasized.**
- 5) What does neonatal encephalopathy mean? **Babies born with neurological damage due to insufficient oxygen or blood supply in the womb.**
- 6) What ground-breaking research is Hamad Hospital conducting to treat babies with neonatal encephalopathy? **Using magnesium sulphate in addition to the cooling method**
- 7) What is a control group used for in a study? **It allows researchers to compare results in a study fairly.**
- 8) What is a double-blind placebo control study? **Some patients receive a placebo, and some get the drug. A placebo is meant to mimic a treatment when in fact there is no treatment being given.**
- 9) Who was first to use a control group? **Al-Razi**
- 10) What was Al-Razi studying when he used a control group? **Meningitis**
- 11) Where is Al-Razi from? **Born near Tehran in Iran in the mid 9<sup>th</sup> century.**
- 12) How did Al-Razi determine where the best place to build a hospital was? **He conducted an experiment by hanging up meat in various locations and he determined that where the meat did not rot had the cleanest air and thereby was the cleanest place to build a hospital.**
- 13) Who in the 17<sup>th</sup> century was credited with ground-breaking research on heart circulation? **William Harvey**
- 14) Who was Al-Nafis? **13<sup>th</sup> century Arab physician.**
- 15) What did Al-Nafis describe in his writings? **Heart circulation and how blood does not move directly from one chamber to the other.**
- 16) What does Dr Magdi Yacoob specialize in? **The heart organ.**
- 17) Al-Nafis, a Syrian scholar, was known for many great contributions but his most important contribution was for... **Blood circulation through the heart**

- 18) What did the Greek physician Galen say about blood circulation and the heart? **The blood passes directly through the heart chambers by tiny holes in the walls of the chambers.**
- 19) How did Al-Nafis explain that Galen was incorrect? **He said there are no holes in the walls of the heart chambers because they are not porous.**
- 20) Al-Nafis described the blood circulating to which organ before returning to the hearts? **lungs**
- 21) When was Al-Nafis's work recognized? **Not during his lifetime but in the 20<sup>th</sup> century when his work was rediscovered.**
- 22) Where did hospitals giving free medicine and treatment first appear? **Cairo in Egypt, Cordoba in Spain, and Damascus in Syria**
- 23) Al-Sina's text Canon of Medicine was used for how long around the world? **500 years**
- 24) What are some benefits of lavender? **Anti-bacterial and relaxation**
- 25) What are some benefits of wormwood? **treats cold symptoms.**
- 26) What are some benefits of sage? **It is good for the stomach and cramps.**
- 27) What are some benefits of black cumin? **It is an anti-toxin, used against bites and rheumatoid.**
- 28) How was knowledge spread through out the Islamic Empire? **The Chinese art of making paper making was adopted which allowed the written transfer of ideas to move quicker.**
- 29) What made Chinese paper better than the local paper? **More durable, lighter, and more easily bound into books.**
- 30) What is the connection between the Islamic Golden Age and the Renaissance? **The texts of the Islamic Golden Age were the foundational knowledge used to propel the renaissance.**
- 31) What is a genome? **The complex genetic code contained in every one of our cells it is unique for everyone.**
- 32) What does a genome sequencer do? **The genetic material is chopped into small pieces examined and then reassembled.**
- 33) How long did it take to sequence the first human genome? **10 years**
- 34) How long does it take to sequence a genome today? **6-10 days**

**Curriculum Expectations Gr 10 Science: Biology**

**Big Ideas**

- Plants and animals, including humans, are made of specialized cells, tissues, and organs that are organized into systems.
- Developments in medicine and medical technology can have social and ethical implications.

**Career Exploration**

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., meteorologist, medical illustrator, geochemist, optical physicist) and the education and training necessary for these careers

A2.2 identify scientists, including Canadians, who have made a contribution to the fields of science under study

**Relating Science to Technology, Society and the Environment**

B1.1 analyse, on the basis of research, ethical issues related to a technological development in the field of systems biology (e.g., cloning, stemcell research, live organ transplants, transgenic transplants), and communicate their findings [IP, PR, AI, C]

**Developing Basic Skills of Investigation and Communication**

B2.7 use a research process to investigate a disease or abnormality related to tissues, organs, or systems of humans or plants (e.g., heart disease, tobacco mosaic virus, wheat rust) [IP, PR, C]

**Understanding Basic Concepts**

B3.4 explain the primary functions of a variety of systems in animals (e.g., the circulatory system transports materials through the organism; the respiratory system supplies oxygen to and removes carbon dioxide from the body)

**Gr 11 Biology Curriculum Expectations**

**Big Ideas**

- Genetic research and biotechnology have social, environmental, and ethical implications

**Career Exploration**

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., zoologist, botanist, geneticist, ecologist, pharmacologist, farmer, forester, horticulturalist) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians, to the fields under study

### Genetic Processes

D1.2 evaluate, on the basis of research, the importance of some recent contributions to knowledge, techniques, and technologies related to genetic processes (e.g., research into the cystic fibrosis gene; the use of safflowers to produce insulin for human use) [IP, PR, AI, C]

D3.3 explain the concepts of genotype, phenotype, dominance, incomplete dominance, codominance, recessiveness, and sex linkage according to Mendelian laws of inheritance

### Animals: Structure and Function

E3.2 explain the anatomy of the digestive system and the importance of digestion in providing nutrients needed for energy and growth (e.g., the body's mechanical and chemical processes digest food, which provides the proteins needed to build muscle, and the fibre, water, vitamins, and minerals needed to regulate body processes)

E3.3 explain the anatomy of the circulatory system (e.g., blood components, blood vessels, the heart) and its function in transporting substances that are vital to health

E3.4 describe some disorders related to the respiratory, digestive, and circulatory systems (e.g., asthma, emphysema, ulcers, colitis, cardiac arrest, arteriosclerosis)

### Plants: Anatomy, Growth and Function

F1.2 evaluate, on the basis of research, ways in which different societies or cultures have used plants to sustain human populations while supporting environmental sustainability (e.g., sustainable agricultural practices in developing countries such as crop rotation and seed saving; traditional Aboriginal corn production practices) [IP, PR, AI, C]

## Gr 11 Biology College Curriculum Expectations

### Big Ideas

- Genetic research and biotechnology have social, environmental, and ethical implications

### Career Exploration

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., food science technologist, medical laboratory technologist, dental hygienist, outpost clinic/primary care nurse, respiratory therapist, veterinary technician, water or wastewater technician) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians, to the fields under study

### Cellular Biology

B1.1 evaluate the effectiveness of medical devices and technologies that are intended to aid cellular functions or processes

## Genetics

D1.2 evaluate, on the basis of research, some of the effects of genetic research and biotechnology (e.g., genetically modified organisms [GMOs]) on the environment [IP, PR, AI, C]

## Anatomy of Mammals

E1.1 analyse the social or economic impact of a medical device or technology related to the treatment of the human circulatory, respiratory, or digestive system (e.g., a pacemaker, a heartlung bypass machine, kidney dialysis) [AI, C]

E3.3 describe the anatomy and physiology of the digestive system (including the mouth, epiglottis, esophagus, stomach, intestines, liver, and pancreas), the mechanisms of peristalsis, absorption, and mechanical and chemical digestion, and the function of the kidneys

E3.1 describe the anatomy and physiology of the circulatory system (including the atrium, ventricles, valves, aorta, pulmonary artery, vena cava, capillaries, veins, arteries, blood cells, and platelets), the mechanisms of blood pressure, and the function of the spleen

## Gr 12 Biology Curriculum Expectations

### Big Ideas

- Genetic research and biotechnology have social, legal, and ethical implications.

### Career Exploration

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., scientific journalist, fisheries and wildlife officer, physician, infectious disease researcher, geneticist) and the education and training necessary for these careers A2.2 describe the contributions of scientists, including Canadians (e.g., Evelyn Roden Nelson, Maude Menten, Albert Juan Aguayo, Kimberley J. Fernie, Michael Archer), to the fields under study

### Molecular Genetics

D3.7 describe, on the basis of research, some of the historical scientific contributions that have advanced our understanding of molecular genetics

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## Science in a Golden Age: Answers to Worksheets

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