



ISSN: 2617-6548

URL: [www.ijirss.com](http://www.ijirss.com)



## The pearl stone in the Arab Scientific heritage from the Umayyad Era to the end of the Mamluk Era (41- 923 AH/ 662-1517AD): A cultural historical study

 Salih Maddah Aljedani<sup>1\*</sup>,  Anwar Mahmoud Zanaty<sup>2</sup>,  Saad Saeed Alqarni<sup>3</sup>

<sup>1</sup>Faculty of Social Sciences, Department of History and Civilization, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia.

<sup>2</sup>Faculty of Arts, Department of History, Ain Shams University, Cairo, Egypt.

<sup>3</sup>Faculty of Social Sciences, Department of History and Civilization, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia.

Corresponding author: Salih Maddah Aljedani (Email: [SMALJEDANI@imamu.edu.sa](mailto:SMALJEDANI@imamu.edu.sa))

### Abstract

The study begins by documenting the remarkable Arabic lexical and taxonomic richness. It then proceeds to the core thesis: an analysis of the theory that pearls form from raindrops. The study meticulously uncovers a pattern of "false attribution"; it demonstrates that what influential Arabic sources such as al-Tifāshī and al-Qabjāqī transmitted as Aristotle's teaching was, in truth, a hybrid Eastern myth falsely ascribed to him to confer legitimacy. This reveals a case of "circular reporting." While later exegetes like Sheikh al-Rabwa resorted to an "interpretive retreat," claiming the pseudo-Aristotelian text was merely "symbol and allegory," the research highlights the genius of a parallel, empirically grounded track embodied by al-Bīrūnī. It is worth mentioning that al-Bīrūnī deliberately avoided explaining the pearl's origin, focusing instead on a precise physical analysis of its behavior. The study then lays facts outside the Aristotelian myth, particularly those of Yūḥannā Ibn Māsawayh. It shows how Ibn Māsawayh produced the earliest geopolitical atlas of pearl fisheries, pioneering principles of marine resource "sustainability management" by documenting the "fallowing" system (a 14-year diving moratorium). He also developed a morphological and economic classification of pearls that surpassed later works. In the medical domain, the analysis traces a shift from magical to laboratory-based application, documenting how al-Bīrūnī and al-Tifāshī transformed the pearl into an "examined substance" through purification protocols, with al-Tifāshī notably applying a comparative experimental method to its dissolution in acids.

**Keywords:** Empirical observation, Historical epistemology, Pearl fisheries, Medicinal uses, Pearl, Arabic scientific heritage, Pseudo-epigraphy, Pseudo-Aristotle.

DOI: 10.53894/ijirss.v9i5.11691

**Funding:** This study received no specific financial support.

**History: Received:** 13 March 2026 / **Revised:** 7 May 2026 / **Accepted:** 12 May 2026 / **Published:** 25 May 2026

**Copyright:** © 2026 by the authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

**Competing Interests:** The authors declare that they have no competing interests.

**Authors' Contributions:** All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

**Transparency:** The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

**Publisher:** Innovative Research Publishing

## 1. Introduction

In contemporary parlance, pearls are classified alongside precious and semi-precious gemstones. They are exquisite natural products distinguished by their beauty and their noble, fascinating characteristics. While they share with most rare and valuable stones the characteristic of being small in size, pearls stand apart from all other materials historically designated as "gemstones" in the past centuries by virtue of their origin; being harvested from the depths of seas and rivers [1].

The Persians were acquainted with pearls as early as seven centuries before the Common Era, as were the Ancient Egyptians, whose knowledge of them dates back to approximately 3200 BC. Furthermore, pearls are mentioned in Chinese literature dating back to 2350 BC. However, the modern status of the pearl as the most exquisite of gemstones was firmly established by the Romans around 300 BC. The Romans regarded pearls as a symbol of pomp and luxury, enacting laws that prohibited anyone who had not attained a specific social rank from wearing them. It is even said that the discovery of pearls in the streams of the British Isles played a role in motivating Caesar to press forward with his military campaigns into the far west of them. During the era of Rome's ascendancy, the desire to acquire pearls reached the level of obsession.

Throughout the eighteenth and nineteenth centuries, the escalating demand for pearls led to their extreme scarcity, causing their value to soar dramatically. With the dawn of the twentieth century, new pearl fisheries were discovered, resulting in a substantial increase in supply; however, demand rose in tandem with this supply, enabling pearls to retain their status as the world's premier gemstone [2].

Historians frequently overlooked the significant observations and insights regarding pearls contributed by Arab and Muslim scholars. This underscores the importance of this research in which we have cataloged all Arabic scientific literature addressing pearls, examining them through the lens of their physical properties, value, varieties, and formation processes.

### 1.1. Research Significance

The significance of this study emanates from the fact that it is the first scientific study – as far as the researcher knows – that discusses the knowledge of Arab and Muslim scholars about pearls and the seas and rivers from which they used to extract them during the period from the early civilizations until the end of the Mamlūk era.

### 1.2. Research Objectives

The main goal of this study is to shed light on the most important scientific achievements of the Arab and Muslim scholars regarding the manner in which they determined the properties, benefits, and applications of pearls.

### 1.3. Research Questions

The research will answer a major question, which is: What are the novel scientific and practical additions that Arab and Muslim scholars have added to the science of pearls during the period from the early civilizations until the end of the Mamlūk era? Four questions branch out from this major question, which are:

1. Have there been any previous studies about the Muslims knowledge of pearls, and what is particularly important about such knowledge?
2. What is the value of the pearls and its applications compared to other stones during the Islamic eras subject matter of this study?
3. What are the locations of pearls diving grounds identified by Muslim authors?
4. When did the pearls trade start to flourish in the Muslim world ?

### 1.4. Research Methodology

This research adopted the historical, analytical, critical and descriptive research method in which scientific material is collected from the most reliable sources and then arranged, classified and presented in the form of a descriptive, analytical and critical study, by comparing it with the scientific material contained in the contemporary sources.

## 2. Pearls Arabic Terminology

The word Arab word *lu'lu'* of pearls, pluralized as *la'āli'*, is frequently used as a synonym for *durr*, another Arabic

word for pearls. However, the semantic distinction between the two can be precisely defined within the Arabic language: *durr* refers to imperforated pearls, whereas *lu'lu'* refers to pearls that have been pierced and prepared for use as jewelry or for other purposes.

Among Arabs, a pierced pearl is also referred to as a *jumāna* or *shadhra*; conversely, if it is not pierced, it is designated as *durr*, *habb*, or *kharā'id*. Furthermore, a pearl is termed *al-fārah* or *al-mudāhrajā* if it possesses a silvery-white or pinkish hue [3].

Thus, we observe a rich abundance of Arabic terms for pearls a nomenclature that arguably surpasses that of all preceding and succeeding civilizations in its precise differentiation between pierced and whole specimens.

### 3. Theories of Pearl Formation

Pearls are classified as organic products and gemstones, though they also share affinities with minerals. Nevertheless, the fundamental distinction between pearls and true minerals was well understood: the former is prone to rapid discoloration due to its biological (animal) origin [4].

Throughout history, scholars from every civilization have endeavored to understand the process by which pearls form within oysters, formulating various theories to explain this natural phenomenon.

Chemically, pearls consist primarily of calcium carbonate ( $\text{CaCO}_3$ ), which the oyster extracts from seawater. The process of pearl formation occurs gradually, layer by layer; as these layers solidify typically assuming a white hue they ultimately coalesce to form a pearl [5].

The formation process begins when a foreign object such as a grain of sand or a microscopic parasite enters the open shell of a mollusk resting on the ocean floor. In an attempt to protect itself from the irritation caused by this object, the mollusk encases the intruder in a layer of "nacre" the very same substance that lines the interior of the shell and is known as "mother-of-pearl." As long as the foreign object remains within the shell, the oyster continues to deposit successive layers of nacre over it a process that may take up to 18 years [2].

The composition of a pearl is identical to that of nacre (mother-of-pearl), yet it features concentric layers that arrange the aragonite crystals in a radial pattern. A pearl's hardness ranges from 2 to 3.5 on the Mohs scale, while its specific gravity falls between 2.5 and 2.7.

Pearls are predominantly white, pale yellow, or bluish in color; however, they may appear in a diverse array of hues, including pink, yellow, purple, red, green, blue, brown, or black. Their transparency ranges from semi-transparent to opaque, while their luster often described simply as "pearly" may exhibit iridescence resulting from the phenomenon of light interference. The finest pearls are those characterized by a spherical shape and iridescent luster, and are free of blemishes while possessing a degree of translucency. High-quality black pearls are highly prized, though they generally do not rival the value of top-tier white pearls.

"Baroque" pearls, conversely, assume irregular shapes; however, demand for them increases significantly when they possess exceptional coloration. "Button" pearls are distinguished as their name suggests by a flattened base, whereas "blister" pearls are shell growths triggered by the presence of a specific parasite. Due to their relative softness, pearls are susceptible to scratching; should their original luster be lost, it is rarely recoverable, which is a feat achievable only by carefully peeling away several of the outer layers. Furthermore, pearls are adversely affected by acids and perspiration, and indeed, the mere passage of time is sufficient to cause their deterioration. For, in the end, the organic substance known as "conchiolin" eventually decomposes [6].

#### 3.1. Chinese Theories

Pearls held a position of special significance among the Chinese people. They believed that pearls possessed magical properties, owing to the presence of the "water element" within their very essence. Consequently, they were thought to serve as guides pointing to the locations of freshwater wells in the desert and revealing the hidden treasures of the "Kings of the Jinn" at the bottom of the sea. These mystical attributes were most famously embodied in the *Great Pearl, Revealer of Secret*, a gem presented as a gift by the King of Kapisa to Emperor Xuanzong: an account documented by numerous writers during the 9th and 10th centuries AD. Furthermore, the Chinese regarded the pearl as "Yin" perceiving it as a feminine, lunar substance nurtured within the heart of the oyster that housed it. They also held the belief that the "pearl embryo" situated deep within the oyster developed in accordance with the phases of the moon [7].

#### 3.2. Greeks Theories

Theophrastus (d. 287 BC) did not dwell extensively on the origin of pearls; rather, he contented himself with the statement: "Among the select gemstones, one finds the pearl, which it is naturally translucent, and precious necklaces are fashioned therefrom. Pearls are extracted from a shell resembling the human ear, but smaller residing in the abdomen of a larger shell. Pearls are harvested in India and certain islands of the Red Sea [8].

#### 3.3. Romans Theories

The roots of the theory positing that pearl oysters are fertilized by dew during specific seasons can be traced back to Pliny. It was alleged that the fruit of this fertilization was the pearl; a notion that might have seemed logical to an observer with a vivid imagination, one who drew a connection between the appearance of pearls and the dew droplets glistening upon the grass in the early morning [1].

In this context, however, we cannot regard Pliny as the original progenitor of this theory about the origin of pearls. Pliny was, in fact, translating from lost Greek sources. The Greek derived their information from accounts of trade with the

East (specifically, the Pearl Route). Thus, the theory migrated from the East to the West (to Pliny), only to eventually return to the East, now cloaked in the prestige of "Greek" authority (specifically, that of the pseudo-Aristotle).

### 3.4. Arab and Muslim Theories

During the Middle Ages, the name of Aristotle served as a veritable "trademark" in the form of a prestigious label bestowed upon any text intended to gain widespread circulation. *Kitāb al-Aḥjār* (The Book of Stones) attributed to Aristotle is, in reality, a pseudepigraphal text likely composed in either Syriac or Arabic during the 9<sup>th</sup> century AD and bears absolutely no connection to the historical Greek philosopher, Aristotle. The statement that the Arabs transmitted is not truly "Aristotelian"; rather, it is a hybrid of Persian and Indian myths. Attributing this theory to Aristotle served as a means of "baptizing" the myth in the waters of science.

In modern scholarship, this phenomenon is known as "circular reporting." An anonymous author writes a text and attributes it to a reputable authority; subsequent researchers then cite this "imaginary" source without consulting the original work, until the error eventually solidifies into a "historical fact" validated not by empirical evidence, but by sheer repetition.

One might well ask: Why did the Arabs not attribute this theory regarding the origin of pearls to Pliny the Elder, choosing instead to credit the spurious Aristotle? The most logical explanation is that the mere presence of this theory in Pliny's writings does not necessarily imply a "Latin origin." Pliny himself was primarily a compiler of information, frequently drawing upon Alexandrian and Eastern sources whose original texts have since been lost. By "Eastern," we refer here to the geographical genesis of the myth specifically; the warm waters of the Arabian Gulf and the Indian Ocean. Yahya Ibn Māsawayh (d. 243 AH / 857 AD) was perhaps the first to attempt to understand the dynamics of pearl formation within a living organism. His approach can be outlined as follows:

## 4. Biological and Anatomical Characteristics of Oysters

Ibn Māsawayh began by dissecting the oyster which he termed the *al-dabba* (creature) describing its internal components based on what was visible to the naked eye at the time:

- External Structure: An outer integument consisting of two conjoined shells.
- Soft Tissues: The black flesh, the fat (located adjacent to the mouth), and the "water foam" (representing vital fluids).
- Functional Organs: He assigned the terms "mouth" and "ears" to the oyster's apertures and vital parts names that reflects an attempt to animate the organism in order to comprehend the mechanisms of its feeding and formation.

### 4.1. Life Cycle and Age-Based Classification

Ibn Māsawayh devised a classification system based on the oyster's developmental stage:

- Al-Bulbul (The Young Oyster): He described it as "swimming and grazing collectively, much like locusts", which is a remarkably accurate observation regarding the movement of larvae and juvenile oysters prior to their settlement.
- Al-Sadaf (The Mature Oyster): This refers to the oyster that settles on the seabed (*al-qarar*) and attaches itself to marine invertebrates or rocks, which he described as being solitary in nature and possessing less flesh.



**Figure 1.**

Open cleaned oyster with pearl isolated on white interior tissue.

Source: <https://stock.adobe.com/in/search?filters%5Bcontent>

#### 4.2. Pearls Morphology

Ibn Māsawayh established a correlation between the specific location where a pearl develops within the oyster and its subsequent quality and geometric shape:

- Mouth Pearls (*Al-Mudahraj*): Pearls situated adjacent to the mouth constitute the highest quality and perfect spherical shape. Ancient divers believed that the oyster would roll the pearl within its mouth in order to polish it.
- Black-Edge Pearls: Any part of the pearl situated away from the dark mantle tissue is considered of just fair quality, as any part adhering to this black tissue is deemed defective or clay-like (as dark organic matter may have intruded into its composition).
- Ear Pearls: The growth of pearls within the ears begins as sand-like granules that subsequently increase in size, which is an accurate description of the initial stages of nucleus formation.

#### 4.3. Environmental and Climatic Influences

Ibn Māsawayh established a correlation between the quality of a pearl-harvesting season and various natural phenomena:

- The Impact of Rain: He linked the large size of the bulbul (the pearl-bearing oyster) and the abundance of pearls to the rains occurring early in the year. This reflects an ancient belief associating rainfall with the growth of marine organisms (possibly due to changes in water salinity and the availability of nutrients).
- The Impact of Sun and Wind: He attributed the lack of color (the fading of luster) in pearls found within dead shells washed ashore to the effects of the sun and wind. He also described a process of "peeling" to reveal the pristine pearl lying beneath this dull, outer layer.

He then discussed specific and exceptional varieties of pearls, noting the following:

- Al-Tawr (the phase): A hard pearl resembling bone or stone. It is heavy in weight (reaching up to five mithqals), extremely rare (found only in the deepest, most prolific oyster beds), and commands a very high value.
- Adhering Pearls: These are pearls that grow attached to the interior surface of the shell known today as *Blister Pearls*" They cannot be extracted without breaking the shell itself.
- Malformations: He described various anomalous types some resembling cowrie shells, others resembling animal droppings that look like structural deformities within the pearl's calcareous composition.



**Figure 2.**

Irregular oval or egg shaped pearls on beige fabric.

Source: <https://stock.adobe.com/in/search?filters%5Bcontent>.

He noted that pearls found within dead, cracked shells washed up on the shores still possess economic value despite their "dead color" as they can be restored by peeling away the outermost layer. He also highlighted the "losses incurred by divers" when the oyster dies and its pearls scatter into the sea, subsequently deteriorating [9].

Al-Tifāshi (d. 651 AH / 1253 AD) attempted to reconcile the animal, plant, and mineral kingdoms within a single organism, much like *coral reefs* in modern science (which exhibit characteristics of mineral, plant, and animal life). Furthermore Al-Tifāshi described *veins* and *tree-like branching* as representing a distorted visual interpretation of the *byssus thread filaments* secreted by the oyster to anchor itself to rocks [10]. [An observer of antiquity or a plagiarizing author likened these threads with plant-like roots, thereby leading to the construction of an entire theory transforming oysters into plants, a theory founded entirely upon a simple anatomical misconception.

With al-Qibjāqi (d. 681 AH / 1282 AD), we encounter the first mention of the concept of stratification in the formation of pearls; a concept distinct from Aristotle's theory. He described it saying: "One of its inherent characteristics is that it consists of thin lamellae, arranged layer upon layer [11]. Indeed, pearls are composed of thousands of extremely thin layers of aragonite (crystalline calcium carbonate), bound together by a colloidal protein substance known as conchiolin. The mantle of the oyster secretes these layers one by one around the irritant material. This laminar structure is responsible for the phenomenon of iridescence, as light refracts and reflects through these thin scales."

Shams al-Dīn Abu Abdullah known as Sheikh al-Rabwah (d. 727 AH / 1327 CE) followed Aristotle's theory saying: "The astute observer maintains that this statement by Aristotle is merely a symbol and an allegory [12]. Here, Sheikh al-Rabwah engaged in an epistemological evasion to shield Aristotle's scientific authority from empirical refutation. By doing so, he intended to achieve two objectives:

1. To resolve sensory contradiction: The astute observer realizes that describing the pearl as a tree that strikes roots and is harvested directly conflicts with the sensory observations of divers, who extract oysters as discrete organisms rather than as underwater forests. Consequently, he invoked the concept of "symbolism" to reconcile the discrepancy between the (sacrosanct Aristotelian text) and (empirical reality).
2. To encode ancient chemistry (Alchemy): Within the structuralism thought of that era, biological terminology was frequently employed as symbolic shorthand for chemical processes. *Rain* might symbolize the spirit; the *shell*, the body or the crucible; and *vegetative growth*, the process of *al-tadbīr* the chemical maturation required to attain the ultimate essence the pearl.

This represents a desperate hermeneutical attempt by Sheikh al-Rabwah to conflate natural history with metaphysical fantasy, where the phrase *symbol and allegory* constitutes an implicit admission that a direct physical description had failed to align with reality, and an attempt to shift the text from the realm of *descriptive science* to that of *allusive philosophy* was made.

According to modern philosophy of science specifically Thomas Kuhn's approach regarding the paradigm or guiding model, what Sheikh al-Rabwah has done is termed the *accumulation of anomalies*. When scholars begin to characterize foundational texts as mere symbols or riddles, this means that the paradigm has begun to crumble, even if no alternative has yet emerged. It constitutes, in essence, an escape from materialist interpretation, but it is a positive escape, for it implicitly acknowledges the existence of a gap between revealed tradition and rational intellect.

Curiously, while Sheikh al-Rabwah acknowledged the concept of stratification within the shell itself, he failed to recognize it in the actual formation of the pearl [12]. Thus he indicated that: "From the pearlescent layers of the shell, the oyster fashions laminas resembling pearls known as *pearl veins*, with each individual shell consisting of one hundred layers, each possessing two distinct faces; where a profound lesson lies for those of refined spiritual sensibility and those of Sufism and philosophy."

Ibn al-Akfāni (d. 749 AH / 1348 AD) who appeared twenty-one years after Sheikh al-Rabwah was of the opinion that: "The creature within which pearls are generated is a type of bivalve shell. It possesses slender appendages, is viscous in nature, and opens and closes at its own volition. It moves in schools and congregates densely around feeding grounds. Scholars have differed regarding its generation within this shell: some likened it with an egg forms within an oviparous animal. Others, however, assert that the creature rises to the sea's surface during the month of April; the shell then opens to receive the falling rainwater, which subsequently congeals into a pearl. This account was recorded by Nasr al-Jawhari, as well as by many others.

Upon closer examination, I believe there is no inherent contradiction between these two views. The pearl forms within the shell in a manner analogous to the formation of an egg, waiting for the April rainwater imparts the seminal fluid.

Al-Kindi observed that the pearl lies within this creature inside the shell; while the finest quality of pearls is those situated nearest to the creature's mouth and ear-like structures.

Furthermore, it has also been stated that large pearls form specifically within the creature's throat, growing in size as layers accumulate around them. This is evidenced by the distinct layers of the pearl, with the innermost layers closely resembling the outermost ones, and all of them look like the innermost part of the shell itself [13].

Moving forward to the early 15<sup>th</sup> century AD, we find Al-Qalqashandi (d. 821 AH / 1418 AD) saying: "The pearl forms inside the shell. The host creature is a marine animal with hard shell-like exterior akin to that of a snail. Divers retrieve these shells from the seabed, and upon surfacing, they extract the pearls from its stomach [14].

The last to address the origin of pearls was Shihāb al-Dīn Muhammad Ibn Ahmad Ibn Mansūr al-Abshīhi (d. 852 AH / 1448 CE); [15] a scholar who emerged during an era in which *transmission* took precedence over *critical inquiry*, and he didn't come with something new beyond the contributions of his predecessors. Indeed, in the history of science, whenever a theory migrates from the *scholarly laboratory* as seen with Ibn al-Akfāni, to the realm of *general literature* as seen with al-Abshīhi, it inevitably forfeits its intellectual rigor, and transforms into a literature of marvels. In his work *Al-Mustatraf*, al-

Abshīhi did not write for scientists or administrative scribes; rather, he wrote for the general public, catering for moral instruction culture and intellectual entertainment. Thus he moved away from scientific precision in favor of mythological storytelling.



**Figure 3.**

A big collection of white and yellow pearls.

Source: <https://stock.adobe.com/in/search?filters%5Bcontent>

Thus, the Arabic theory regarding the origin of pearls evolved through three distinct stages: It began with a phase of empirical silence among early scholars such as Ibn Māsawayh, characterized by a strict adherence to sensory observation. It then transitioned to the stage of the circulating myth exemplified by Abu Bakr al-Khwārizmi, which drew upon an Eastern intellectual heritage linking the formation of pearls to rainfall and celestial phenomena. The theory reached its zenith during the phase of philosophical fabrication commencing with Al-Tifāshi, wherein superstition was infused with spurious Aristotelian weight, in order to legitimize the notion that an animal could transform into a plant. Consequently, this theory did not constitute a scientific discovery; rather, it was an *epistemological synthesis* that cloaked sailors' myths in the prestige of pseudo-Greek philosophy; a process that effectively stifled field-based critique in favor of *textual interpretation* for centuries.

### **5. Optical and Mechanical Properties of Pearls**

Abu al-Rayhān Al-Birūni (d. 440 AH / 1047 AD) recounted a concept known in his era as the wateriness of the fresh pearl, stating that: "As for the moisture attributed to the pearl, its true meaning water of luster, radiance, textural richness, and absolute purity. Since moisture is a quality inherent to the very essence of water, it represents it metaphorically in discourse. Furthermore, there is a specific rationale albeit, a subtle one, behind the pearl's moisture: whereas all other gemstones, when placed upon the ground, come to rest immediately, the pearl will roll away at the slightest incline of the surface. Similarly, it tends to slip between one's fingers due to the difficulty of securing a firm grip upon it. It resembles moist apple or pear seeds when they are pressed between two fingers, causing them to shoot away over a considerable distance; which is due to smoothness brought about by moistening and inherent slipperiness [16].



**Figure 4.**  
White pearls necklace on a black background.  
Source: [tps://stock.adobe.com/in/search?filters%5Bcontent](https://stock.adobe.com/in/search?filters%5Bcontent).

Here, Al-Birūni describes three complex physical phenomena in pearl:

1. The Wateriness of the Pearl: What he termed the *water of luster* corresponds, in modern science, to the phenomenon of *optical interference*. Pearls are composed of successive microscopic layers of *nacre* (aragonite platelets). When light strikes the pearl, it reflects off the surfaces of its various layers, creating a deep shimmer that appears as though water were flowing within the gem.

2. Smoothness and Slipperiness: Al-Birūni spoke of the moistening of smoothness. In modern terms, we now understand that the surface of a pearl despite its apparent smoothness possesses a microscopic, "scaly" structure. This structure, combined with an extremely thin layer of conchiolin protein, creates a sensation of "slippage" when held by the fingers; a mechanism that explains the *slipping away* phenomenon he so accurately described.

3. Spherical Geometry: The rolling of a pearl with minimal inclination is an application of the principle of torque distribution in perfectly spherical bodies. A natural round pearl possesses a perfectly balanced center of gravity, which minimizes rolling resistance.

It is noteworthy that Al-Birūni, in this context, did not explain how pearls form; rather, he explained how they behave physically. This approach saved him from falling into the trap of allusion and symbolism, a pitfall into which Sheikh al-Rabwah would later stumble.

## 6. Types of Pearls

Pearl varieties range in color from the purest rosy white to every conceivable hue and spectrum. Produced by various types of shelled creatures, the finest gemstones are extracted from saltwater mollusks known as *Meleagrina margaritifera* that inhabit tropical seas. Ranking second in importance are freshwater mussels, found in abundance in the tributaries of the Mississippi River and in the numerous streams of England and Scotland. Although the interior of an ordinary oyster shell is not attractive, the shell of a pearl-bearing oyster is of exquisite beauty. Nine-tenths of the revenue generated by an average pearl fishery derives from the sale of the shells themselves used in the manufacture of buttons, knife handles, and similar items. Furthermore, despite the numerous qualities often attributed to edible oysters such as the "Blue Point" and "Cotuit" varieties, the production of precious pearls is not among these attributes.



**Figure 5.**  
 Pearls of various colors with three partially or wholly malformed.  
 Source: <https://in.images.search.yahoo.com/search/images>

In the past, pearls brought from the East were known as *Oriental* pearls, which are distinguished by soft luster that renders them superior to others. Later, when pearl-bearing mollusks of the same species found in Ceylon and the Red Sea were discovered in other parts of the world, the term *Orient* expanded to encompass them as well, which is applied now to almost all saltwater pearls to distinguish them from freshwater varieties [2].

Yahya Ibn Māsawayh did not limit himself to merely an aesthetic description of pearls, rather, he established a precise economic system linking a pearl's origin, weight, and shape to its monetary value, Ibn Māsawayh [9] which he did by adopting *al-Mudahraj* as the standard monetary unit of measurement for all other varieties:

#### 6.1. Varieties Classified by Shape and Form

1. Al-Mudahraj: This variety is also called al-Qār, the largest of which is termed al-Qaṭarī which may reach a weight of one mithqāl. It serves as the benchmark for measuring other varieties.
2. Al-Khāydār (or al-Makhrūṭa): A pearl in which one end is narrower than the other, resembling a cone. Most examples of this variety originate in Oman, and can reach a weight of two mithqāls, with a value equivalent to half of al-Mudahraj.
3. Al-Muqa'adah: These are small pearls frequently found among al-Qaṭarī pearls, with larger ones found among al-'Umānī pearls. Their price is half of al-Mudahraj.
4. Al-'Adasa: A full-bodied, substantial pearl typically positioned in the center of a strand. It is found among both al-Qaṭarī and al-'Umānī pearls, and reach two-thirds of al-Mudahraj in value.
5. Al-Murtafi' (The Elevated Pearl): This refers to pearls strung on a thread arranged in a specific hierarchy for display and sale.
6. Al-Labani: Resembles frankincense in its fineness, length, and curvature. It is valued at one-third of Al-Mudahraj.

#### 6.2. Varieties Classified by Color and Origin

- Al-Maghribi: Highly prized by the people of the North Africa to whom it is imported, and is valued at two-thirds Al-Mudahraj.
- Al-Isfahani: It is distinguished by its intense yellow hue, and is valued at one-third Al-Mudahraj.
- Al-Wardi: This is a reddish-pink small size pearl found in Serendib, Sri Lanka.

#### 6.3. Varieties with Defects and Unique Characteristics

- Al-Khamānaj: Resembles Al-Mudahraj variety, but may be fused to the oyster shell or intensely black in color. It is valued at one-tenth to one-fifth of Al-Mudahraj.
- Al-Duqq: This is a pearl covered in a thick, black outer layer that must be filed away to remove the black layer and reveal a fine-quality pearl. Some of it is boiled to reduce the blackness.
- Al-Tiniyyah: This is a pearl with another pearl nested in its outer shell. The inner pearl is checked against light in order to determine its weight and shape before peeling away.
- Al-Sarāb: A pearl that dries out and cracks over the course of one year; however, if immersed in water for a day or two, it reverts to its natural state.

- Al-Kuroosh: A pearl with a single outer skin and contains foul-smelling black fluid. It needs to be pierced to drain and clean the interior, and be stuffed.
- Al-Munfakh: A pearl that is solid on one side but hollow on the other. It is used in making matching sets and crowns.
- Al-Tawr: Hard, solid pearl.
- Al-Awwal: A pearl with a defective base consisting of mud or black stone surmounted by a high-quality pearl layer.
- Al-Jumanakh: A poor-quality variety with thin outer layers and an interior filled with silt and mud; it is highly fragile and lacks durability.
- Al-Mudarraṣ: These are two or more pearls fused together. If the cluster consists of exactly two pearls, it is suitable for cutting and crafting.
- Al-Muzannar: A pearl featuring one or more distinct bands (or "belts") encircling it. It is found among large Qaṭari pearls and small Sarandib ones and can be treated to raise its value to one thousand dinars.

#### 6.4. Types Classified by Geographic Origin

- The Qulzumī: Named after the Sea of Qulzum (the Red Sea). Al-Birūni describes this variety as being, for the most part; "jagged and irregular" meaning it is of lesser quality in terms of its roundness [16].

#### 6.5. Methods of Fraud and Deception (Artificial vs. Natural)

Al-Birūni exposed the methods of "counterfeiting technology" prevalent in the 5<sup>th</sup> century AH (11<sup>th</sup> century AD):

- Al-Mutabbaq (Laminated Pearl): This is a technique involving the adhesion of two pearl shells, which are then hollowed out and filled with substances such as cheese glue (casein) or sandarac resin to impart a natural weight and appearance.
- The Onion Type: Pearls resemble onion in the way they are wrapped, layer upon layer. This establishes a characteristic that prevents fraud.
- The Use of Shells: Pieces of hard seashells may be polished to mimic the appearance of pearls.
- Chemical Camouflage: The use of "talc" combined with "sublimated mercury," kneaded together with cheese glue, is among the early attempts at creating laboratory-produced pearls.

Al-Birūni described a chemical method for etching shells using [16].

- The Insulating Agent: Wax (to protect the raised areas).
- The Corrosive Agent: "Thaqif Vinegar" (concentrated), to which "Nushadhir" (ammonium chloride) is added, or "Citron Sorrel" (citric acid). This process is precisely what we know today as "Acid Etching."

#### 6.6. The Binary Classification According to Size

Sheikh al-Rabwa adopted a definitive binary classification based on physical bulk [12].

1. Al-Durr (The Larger Pearl): This refers to the premium variety, which he defined as round, clear, translucent and pure, weighing between half a mithqal to one and a half mithqals.
2. Al-Lu'lu' (The Smaller Pearl): This is the term he applied to smaller sizes, with a primary quality of purity and roundness.

#### 6.7. Colors and Their Biological Interpretation (The Theory of Proximity)

This constitutes the most fascinating section of Sheikh al-Rabwa's text, wherein he enumerates the various pearl colors (yellow, red, green, blue) and offers an explanation for their occurrence based on *organic proximity*:

- The Red Color: Results from the pearl being in direct contact with the oyster's spleen.
- The Green Color: Results from the pearl being in direct contact with the oyster's gallbladder.

### 7. Pearl Diving Grounds (Pearl Fisheries)

Pearls are extracted from numerous species of oysters and mussels, most of which belong to the families of Aviculidae (pearl oysters), Unionidae (freshwater mussels), and Mytilidae (brackish water mussels). Pearl diving grounds are distributed along the coasts of India, Ceylon, the Arabian Gulf, the Red Sea, Japan, Australia, the Sulu Archipelago (northeast of Borneo), other Pacific islands, western Central America, Mexico, and the Caribbean Sea.



**Figure 6.**  
Large and colorful freshwater clam pearls with clam open.  
Source: <https://in.images.search.yahoo.com/search/images>

Furthermore, freshwater mussels inhabit the streams of Europe specifically in Great Britain, Czechoslovakia, German Saxony, and Bavaria as well as those of North America, including Canada, Ohio, Indiana, Iowa, Arkansas, and Tennessee, in addition to Japan and China [17]. While pearls are currently harvested from countless sources, the primary sources are still the fisheries of Ceylon and India, the Arabian Gulf, the Red Sea, China, the Malay Archipelago, Australia, and Venezuela [2].

Ibn Māsawayh presented us with the first "geopolitical and economic atlas" of pearl fisheries within the Islamic world and the Far East. He did not describe pearls merely as inanimate objects; rather, he studied them within the broader context of marine geography (oceanography) and sustainable resource management [9].

We can summarize Ibn Māsawayh's contributions in the following points:

### 7.1. Spatial Geography

He divided the world known at that time into four primary production regions:

- The Bahrain Zone (Al-Qatari): This coastline extends from Kāzima (present-day Kuwait) to the Persian Sea. He described it as a shallow diving ground (about three fathoms), a characteristic that leads to elevated water temperatures. He linked this phenomenon to the appearance of yellowness in the pearls, as a result of the marine environment's temperature impact on pearl coloration.
- The Oman and Yemen Zone (Sāmikh): Extending from Muscat and Al-Shih̄r, reaching as far as Socotra, Aden and Barbara (the Horn of Africa). This zone is characterized by its great depth *al-lujja* and the diversity of its output.
- The Red Sea Zone: Extending from Jeddah to Ayla (Aqaba). He described its pearls as "hollow, inflated, and colorless" a scientific description of a specific type of pearl that lacks dense layers of nacre, which is a deficiency resulting from the nature of the local waters or the specific oyster species prevalent in that region.
- The Sarandīb Zone (Sri Lanka): He described this region as the primary source of al-duqq (small pearls), which were utilized by the general populace.

### 7.2. Environmental Management and Sustainability

Here, Ibn Māsawayh revealed the system of "marine agricultural rotation" in Serendib:

- The Following System: He noted that diving operations would continue for 14 years, followed by a suspension for another 14 years.
- Scientific Explanation: This grants the "Bulbul" (small oyster) an opportunity to mature and reproduce, thereby restoring the ecological balance of the coral and oyster colonies a practice we refer to today as *Sustainable Fisheries Management*.
- Prohibition of Overfishing: He forbade the extraction of "wet Bulbul" (immature oysters) to ensure the quality of future harvests.

### 7.3. Distinguishing between Saltwater and Freshwater Pearls

For the first time in ancient texts, we find a clear distinction drawn between:

- Marine Pearls: (Qatari, Omani, and Serendibian).
- Freshwater Pearls: Ibn Māsawayh noted their presence in the Chinese Estuary and described them dry and red, which is a chemically precise description, as the composition of freshwater pearls differs from that of saltwater pearls in terms of their manganese content and mineral impurities factors that directly influence their color tone and hardness.

### 7.4. Physical Analysis of Shapes

Ibn Māsawayh introduced precise geometric classifications for each specific region:

- Al-Minbar: An intermediate form situated between the al-Mudahraj (perfectly spherical) and the al-Mudarras (irregular/jagged).
- Al-Muqa'adah: Pearls featuring a flattened base; that occur in China.
- Al-Manādirah: These are rare pearls distinguished by their unique and singular shapes.

## 8. Economic Value and the Market of Pearls

Ibn Māsawayh established a link between "location" and "price," explaining the following:

- The Kharg Diving Ground: This site yields "gems" (pearls) valued at up to 10,000 dinars per individual piece (weighing one and a half mithqals).
- The Red Sea Pearl: Despite its large size (5 mithqals), its value is low because it is hollow; this confirms that the primary criteria for value are not merely size, but also density and color.

Thus, Ibn Māsawayh was not merely a "gem merchant"; he was also an expert in bio-statistics and economic geography. He recognized that:

1. Salinity and temperature in Bahrain and China determine the color of the pearls (yellow or red).
2. Depth and environmental conditions determine the density of the layers resulting in hollow pearls in Red Sea and solid pearls in Oman.
3. Human management (e.g. in Serendib) constitutes the sole guarantee for the sustainability of marine wealth.

As previously noted, pearl fisheries were distributed across several locations: the Arabian Gulf, the Pacific Ocean, and the strait separating India from the island of Ceylon. This is corroborated by Arabic texts [18].

- Al-Qazwīni notes that "there are plenty of pearls in the Sea of China, as well as diving grounds where pearls are found in fresh water, yielding gems of excellent quality."
- Ibn Māsawayh noted the existence of a pearl diving ground in the Red Sea where the pearls extracted from there are known as Qulzum Pearls.
- Al-Bakri (d. 487 AH / 1094 AD) noted the existence of a pearl source in Yemen [19].
- Another source of pearls is located in the Bahrain Islands [20]
- Another source in in the Arabian Gulf and Kharg [21].
- Al-Mas'ūdī stated: "Diving takes place in four locations: Kharg Island, within the jurisdiction of Fars, the land of Oman, Qatar, and the island of Sarandib [12]."

Al-Tifāshi indicated that: "Pearls are found in many locations; however, the most reliable sources for the finest, most exquisite and precious varieties are in Siraf, Nadīb, Kish, Oman, Bahrain, and Kharg Island off the coast of Persia. The pearls found there represent the most magnificent of all pearl varieties, and any pearls found outside these specific locations are considered to be of negligible value. Likewise, those found in the Sea of Qulzum (the Red Sea) and the rest of the Hijaz coast are of inferior quality, even when they are of exceptional size, they would not command a significant price, as they lack the characteristics of the truly precious pearl varieties. Furthermore, pearls found in deep waters and in locations free of silt and sediment are purer and more lustrous. This is because pearls situated near the water's surface are penetrated by the sun's heat, imparting on them yellowish tint. Conversely, those found in muddy environments are discolored by the noxious vapors arising from the sediment; their yellow hue cannot be removed, as it is an intrinsic characteristic present from the very moment of their formation [10]."

- Abu Mansūr al-Tha'ālibi (d. 429 AH / 1038 AD) noted that pearls are found in Oman [22].
- Ibn al-Akfānī mentioned many renowned diving grounds in the Green Sea [13]
- Al-Qalqashandī (d. 821 AH / 1418 AD) noted that: "There are numerous pearl diving grounds, however, the primary sources for the most precious pearls are found in Sarandib and part of India as well as in Kish, Oman, and Bahrain. The most exquisite pearls of all are those from Kharg Island, situated between Kish and Bahrain. As for the pearls

found in the Red Sea, they are of inferior quality even if a specific pearl happens to be of immense size for they command no significant commercial value [14].

- Pearls are harvested from the Arab Gulf, and Bahrain, in particular, has been a renowned origin since pre-Islamic times [23].
- Historically, sources of pearls were concentrated in Bahrain and Oman [24].
- Pearls were also transported to Mesopotamia from regions within India [5].
- Pearls were not utilized in Ancient Egypt until the Ptolemaic era, [25] although seashells themselves had been employed in Egypt since prehistoric times. Pearls are harvested from the shores of the Red Sea, as well as from the Arabian Gulf [26].
- Baylaq al-Qibjāqi recounted that: "It is said that pearls are found in many locations; however, the primary sources for the finest, most exquisite, and precious specimens are in Sarandib (Sri Lanka), followed by Kish, Oman, and Kharg Island situated between Kish and Bahrain within the Persian realm where the gems produced are considered the most magnificent of all varieties." As for pearls found outside of these specific locations, they are of no significant value. Likewise, those found in the Red Sea as well as in the other seas of Yemen are of inferior quality. Even if a pearl from these regions were of immense size, it would command no substantial price. The reason for this is as follows: pearls situated near the water's surface are penetrated by the sun's heat, which imparts a yellowish tinge to them; conversely, those found in muddy or silt-laden environments are discolored by the noxious vapors arising from the sediment. This yellowness is indelible, as it is an intrinsic characteristic present from the very moment of the pearl's formation, pervading its entire structure from core to surface. However, should a pearl acquire a yellowish tint merely through prolonged use or handling, that discoloration can be cleansed away [11].

## 9. The Therapeutic Uses of Pearls

The use of pearls in Arabic medical treatments began to emerge as early as the 10<sup>th</sup> Calendar century. This is evidenced in the writings of Ibn al-Jazzār al-Qayrawāni (d. 369 AH / 979 CE), who indicated that: "Pearl possesses a balanced temperament being neither excessively hot nor cold, neither dry nor moist. Larger pearls are superior to smaller ones; lustrous pearls are superior to dull ones; and perfectly smooth pearls are superior to those with an uneven or pitted surface. Its specific therapeutic property lies in its efficacy against heart palpitations, as well as against the anxiety and distress often associated with an excess of *black bile* (melancholy). It achieves this by purifying the blood within the heart and attenuating any blood that has become excessively viscous. Furthermore, it serves to dry up excess moisture within the eyes, thereby strengthening the ocular nerves.

Aristotle, for his part, asserted that "anyone who discovers the method of dissolving pearls whether large or small until they transform into a shimmering liquid, and then applies this liquid as a topical ointment to the white patches on the skin associated with vitiligo, will find that the condition vanishes after the very first application. Similarly, for those suffering from a headache caused by irritation of the ocular nerves, administering this liquid as a nasal instillation will alleviate the pain, bringing about a complete cure after the very first dose." "Some physicians have asserted that a suitable substitute for a dirham's weight of imperforated pearls is one and a half dirhams' weight of pure mother-of-pearl [27].

The aforementioned passage by Ibn al-Jazzār al-Qayrawāni represents a fundamental shift in the approach to pearls, effectively moving them from the *treasuries of kings* to the *pharmacy of the physician*. This text reflects the maturity of the Arab medical school in Qayrawān, and its capacity to integrate Aristotelian natural philosophy with clinical practice [28]. This can be summarized in the following points:

### 9.1. Ancient Biomedical Theory

Ibn al-Jazzār described pearls as being "moderate in terms of heat, cold, dryness, and moisture." Within the philosophy of the *Four Humors*, a remedy is rarely described as possessing absolute moderation, which implies that pearls were considered a safe remedy; one with a safe profile that does not disrupt the body's equilibrium, thereby rendering them suitable for inclusion in compound medicines designed to strengthen vital organs (specifically, cardiac remedies) [29].

### 9.2. Biochemistry (Purification of the Heart Blood)

The text establishes a link between pearls and the treatment of heart palpitations and fear. It was believed that pearls served to attenuate the thickened blood resulting from *black bile* (melancholia or depression). As is now known, the chemical composition of pearls consists of up to 90% calcium carbonate (CaCO<sub>3</sub>), in addition to proteinaceous substances (conchiolin) and mineral salts. In traditional medicine, these minerals are believed to aid in soothing both the nervous and circulatory systems; a mechanism that explains their application in treating palpitations triggered by nervous tension [29].

### 9.3. Ophthalmology

Ibn al-Jazzār noted that pearls dry up the moisture present in the eye. Finely ground pearls were historically utilized as a form of kohl (an eye salve). Given their nature as a mildly alkaline and desiccating substance, they were employed to absorb excess secretions, treat minor corneal ulcerations, and strengthen the optic nerves [29].

### 9.4. Dissolution of Pearls and Laboratory Chemistry

Ibn al-Jazzār cites Aristotle (or works attributed to him) regarding the possibility of "dissolving pearls until they become a shimmering liquid." However, pearls do not dissolve in ordinary water; rather, they can be dissolved in weak

acids (such as concentrated vinegar or citric acid). The "shimmering liquid" resulting from dissolving pearls in acid is a solution rich in absorbable calcium ions. Its use in treating *al-bayād* (leukoderma or skin lesions) reflects an early attempt to utilize dissolved minerals in the treatment of intractable skin diseases.

#### 9.5. Sniffing (Nasal Drug Delivery)

The text's reference to "nasal insufflation with pearl water" to treat headaches originating from the optic nerves, represents a highly advanced concept what we today term "intranasal drug administration." The nasal cavity is rich in capillaries situated in close proximity to the brain. Arab physicians recognized that this method offered the most rapid route for delivering the therapeutic effects of analgesic medications to the central nervous system.

#### 9.6. The Theory of Pharmacological Substitutes

The text concludes with a fundamental principle of Arab pharmacology known as *al-ibdāl* (substitution): specifically 1.5 dirhams of pure shell material is equivalent to 1 dirham of imperforated pearl. Physicians understood that the active constituents (calcium carbonate and protein) are present in the shell as well, albeit at a lower concentration and purity level. Consequently, they increased the dosage to one and a half times the weight of the ingredients in order to compensate for the reduced purity relative to that of the pearl. Furthermore, the text emphasizes the necessity of using imperforated pearls to ensure that their natural oils and vital constituents have not been compromised through perforation or prolonged storage.

Thus, Ibn al-Jazzār here views pearls not merely as "gemstones," but rather as a "biochemical substance." His true contribution lay in:

1. Dosage Determination: Establishing substitution ratios between mother-of-pearl and pearls.
2. Targeted Application: Linking pearls to two vital physiological systems (the heart and the brain/nervous system).
3. The Physical Approach: Emphasizing the quality of the material; specifically its physical attributes (being lustrous and smooth) as a prerequisite for therapeutic efficacy; a concept we refer to today as "Quality Control."

This text paves the way for understanding why small pearls known as *al-duqq* were historically sold in pharmacies, and how they evolved from being mere adornments into therapeutic antidotes.

In the Arab East, Abu Bakr al-Khwārizmi Muhammad Ibn al-Abbās (d. 383 AH / 993 AD) recorded a prescription for treating *bahaq* (vitiligo), stating that: "Whoever suffers from *bahaq* should take pearls, grind them together with vinegar, and apply the paste to the affected area; he shall be cured, by the will of God Almighty [30]. He also cited another therapeutic prescription for infertility involving the use of a pearl-based paste, in which he stated: "This is an infallible paste. The procedure involves taking red *bahman* root, *tragacanth gum*, *skink*, *ox gall*, and *dunaj*, two mithqals of each, along with musk, *galangal*, imperforated pearls, and white mustard, one mithqal of each. These ingredients are gathered, ground into a powder, and kneaded with skimmed honey. The mixture is to be consumed for three consecutive days, one mithqal each morning, until the semen is cleansed of impurities. Intercourse is then to be undertaken on the fourth day, whereupon God willing offspring shall be conceived [30].

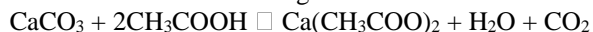
The aforementioned text by Abu Bakr al-Khwārizmi represents a significant practical example of what is known in the history of medicine as "Biochemical Pharmacy," marking a transition from general theoretical speculation to specific "Formulation."

Presented below is my precise scientific analysis of these two texts, deconstructed into their underlying chemical and physiological principles:

#### 9.7. Treatment of Bahaq

The Formulation is done through the grinding of pearls with vinegar as follows:

- Chemical Analysis: Vinegar contains acetic acid ( $\text{CH}_3\text{COOH}$ ), while pearls as previously noted consist of calcium carbonate ( $\text{CaCO}_3$ ). When these two substances are mixed, a chemical reaction ensues, yielding calcium acetate a soluble salt accompanied by the release of carbon dioxide gas.



- Therapeutic Effect: The resulting calcium acetate functions as a mild *exfoliant* and an agent that alters the skin's environment (pH). In cases of *vitiligo* (skin depigmentation), it was believed that this ionic solution rich in dissolved calcium helps stimulate skin cells or "scrub away" the discolored layer and restore natural pigmentation.

##### 9.7.1. The Second Prescription

This prescription is intricate and complex, relying on the principle of "synergy" among its constituent ingredients:

- Imperforated Pearls (Filler and Mineral Agent): Al-Khwārizmi, like Ibn al-Jazzār, insisted that the pearls should be imperforated to guarantee their chemical purity and ensure that their internal cavities remained uncontaminated. Here, the pearls provide trace elements believed to support vital cellular functions.
- The Skink and Ox Gallbladder: The skink (a type of desert lizard) was regarded as one of the most potent "appetite stimulants" and sexual aphrodisiacs in ancient Arabic medicine. Ox gallbladder, meanwhile, contains bile salts that facilitate the emulsification and absorption of the fatty substances, such as musk, present in the prescription.
- Red Bahman and Galangal: These are herbal ingredients renowned for their stimulating effects on blood circulation and their ability to impart warmth on the body, thereby increasing blood perfusion to the reproductive organs.

- **Skimmed Honey:** This serves as the pharmaceutical vehicle. Skimming honey entails boiling and filtering it to remove impurities and surface proteins, thereby ensuring its purity, extending the prescription's shelf life, and preventing fermentation.

#### *9.8. Physiological Analysis*

Al-Khwārizmi indicated that: "Semen should be purified of its turbidity. Turbidity in bodily fluids has been known to reduce vitality, which is the result of an imbalance in the humors or the presence of noxious waste products that hinder fertilization. In contemporary parlance, "clearing the turbidity" may be interpreted as improving semen quality, reducing excessive viscosity, or treating minor infections through the antiseptic agents contained in the prescription namely, mustard, galangal, and musk.

##### *9.8.1. The Therapeutic Protocol*

Al-Khwārizmi established the following precise protocol:

1. **Usage:** Treatment takes three consecutive days; a preparatory phase designed to build up the therapeutic concentration within the body.
2. **Dosage:** One mithqal each morning taken on an empty stomach to ensure maximum intestinal absorption.
3. **Execution:** Sexual intercourse on the fourth day once the full effects of the stimulating and invigorating agents have taken hold.

Al-Khwārizmi demonstrated that pearls were not utilized merely for "seeking blessings or adornment," but were instead treated as a chemically reactive substance:

1. **In Dermatological Treatment:** They were employed as a source of soluble salts, obtained through a chemical reaction with acids, specifically, vinegar.
2. **In Internal Medicine:** They served as a constituent within a complex, vital compound, which is a therapeutic blend designed to enhance metabolism and reproductive capacity.

These texts illustrate that Arab science established a link between chemistry, specifically, the reaction of vinegar with pearls, and physiological functions, such as fertility and skin health, within a single, integrated system.

Abu al-Rayhān Al-Birūni also addressed the use of pearls in medical treatments, offering novel insights and additions, which we summarize as follows [16].

##### *9.8.2. The Concept of "Accidental Poisoning"*

Al-Birūni introduced a new dimension of safety oversight one previously unmentioned by his predecessors. It also serves as a stern warning against a common practice among jewelers, who would often place pearls in their mouths or rub them against their clothing in order to clean them. Al-Birūni established a direct link between this habit and the potential transmission of toxins or infectious agents via the pearls to the patient. He argued that if a pearl were to become contaminated with the saliva of an ailing merchant or with a toxic substance, its subsequent incorporation into medicinal pastes or compounds could result in the poisoning of the patient's internal organs or eyes. Consequently, Al-Birūni devised a medical protocol of washing and repeated perforation through threading of the cord to facilitate mechanical and chemical sterilization prior to pulverization.

##### *9.8.3. The Bio-Ventilation Theory of Decay*

Al-Birūni presented a significant physical explanation regarding the causes of pearl decay and recommended a means by which to arrest it, which is unprecedented in medical literature. He posited that a pearl might harbor within itself decay or worms in the form of organic residues originating from the oyster. He argued that the perforation serves as an air vent that can dissipate the heat that generated decay, and thereby prevent internal decomposition. He drew an analogy between this medical procedure and the drilling of a tooth or perforating a molar to vent the gases and heat responsible for swelling and pain, which is a brilliant conceptual link bridging the biology of pearls with the fields of dentistry and surgery.

##### *9.8.4. Production in the Pharmaceutical Laboratory*

Al-Birūni addressed a subtle professional nuance impacting the quality of medicinal preparations. He noted that the task of perforation, which precedes the medical pulverization process, is typically entrusted to uninformed apprentices, because their hands do not tremble with anxiety over the pearl's monetary value. Here, the physician prioritizes the functional outcome of successful perforation that facilitates ventilation and pulverization over the merchant's concern for material worth. This approach ensures a steady supply of raw materials for pharmaceutical compounding, unhindered by "decision paralysis" that might otherwise arise from the fear of accidental breakage.

##### *9.8.5. Perforation and Pulverization*

While earlier physicians typically requested "imperforated" pearls solely for the sake of purity, Al-Birūni introduced a "mechanical" analysis in which he elucidated what the act of perforation constitutes. In essence it is a form of "partial pulverization." In other words, this constitutes the initial stage in the disintegration of the pearl's solid structure. If the intended purpose is medicinal, drilling exposes the pearl's interior and verifies the quality of its essence before it is incorporated into medicinal pastes, which is an act that serves as a "quality control" measure prior to pharmaceutical manufacturing.

Thus, Al-Birūni elevated the status of the pearl from a mere "healing substance", as viewed by Ibn al-Jazzār, to a subject of empirical examination. In doing so, he introduced the following innovations:

1. A protocol for detoxification against incidental contaminants (deep cleansing).
2. An explanation attributing the spoilage of pearls to internal decay, and positing the necessity of aerating them via drilling, much like dental abscesses.
3. The utilization of drilling as a diagnostic laboratory tool to verify the integrity of the pearl's core prior to pulverization.

Through these contributions, Al-Birūni effectively shifted the application of pearls from the realm of "supernatural phenomena" to the domain of "biophysics."

During the 13<sup>th</sup> Calendar century, the use of pearls in medical therapies underwent further evolution. Al-Tifāshi built upon the work of his predecessors by introducing several key concepts, notably:

#### *9.8.6. The Potency of Solvents*

This constitutes Al-Tifāshi's most significant contribution in which he moved beyond merely mentioning the "dissolution of pearls" to specifically identifying the solvent agent and characterizing the resulting reaction product. He discovered that concentrated citric acid serves to polish the pearl, yet simultaneously transforms it into a substance with a curd-like consistency, a material that fails to adhere to the skin. Conversely, "pungent hot waters" specifically mineral acids or strong alkaline solutions dissolve it into a "tremulous" state that adheres to the surface. Here, Al-Tifāshi describes the physics of "viscosity" and the capacity of "adhesion" exhibited by solutions resulting from chemical reactions, which is a phenomenon known today, within the field of pharmaceutical studies, as "drug retention on the skin."

### **10. Cosmetic Dentistry**

Al-Tifāshi noted that pearl powder "polishes the teeth effectively." Pearls act as a mild abrasive owing to their calcareous nature and their application for polishing teeth represents a novel addition not mentioned in earlier medical texts, which had focused exclusively on the heart and the eyes [10].

### **11. Properties of Aged Pearls**

Al-Tifāshi distinguished between modern pearls and "aged" pearls specifically those found in the soil. He posited that pearls lost in the earth whose organic moisture had desiccated over time were "more suitable" for use in eye drops. This is because they had shed the organic impurities that might otherwise cause irritation, which is an insight that represents an early understanding of the impact of "aging" on the chemical properties of medicinal substances.

### **12. Toxicology**

Al-Tifāshi stated that crushing pearls and administering them orally alongside cow ghee serves as an antidote to poisons. The use of clarified butter acting as a lipid-based binder for fat-soluble toxins in conjunction with pearls, which function as a mild alkali, constitutes a compound designed to coat the stomach lining and inhibit the absorption of toxins. This represents a novel therapeutic application, one not previously documented in earlier texts concerning pharmacological alternatives or dermatological formulations [14].

### **13. Hemostatic Action**

Al-Tifāshi attributed to pearls the specific property of arresting blood flow. This constitutes a novel functional application for pearls in the treatment of wounds or internal hemorrhaging, which is a property likely attributable to their astringent qualities and their calcium salt content.

Thus, Al-Tifāshi was the first to apply the Comparative Experimental Method to the dissolution of pearls. Rather than simply stating, "Pearls dissolve in acid," he experimented with various types of solvents including citron juice versus brackish water and described the physical differences observed in the results, affirming his findings with the statement: "I have tested this myself, and it proved true."

These contributions transformed the pearl into a substance with cosmetic applications for teeth, emergency uses for treating bleeding and poisoning, and laboratory utility in its dissolved form, thereby transcending the confines of the psychiatric and ophthalmological medicine that was prevalent at the time.

Ibn al-Akfāni noted that physicians utilized only virgin imperforated pearls in their medicinal preparations. This practice stemmed from the concern that drilling typically performed using a diamond bit could alter the pearl's chemical properties or contaminate its essence. This specific point was not emphasized with such clarity by either Al-Birūni or Ibn Māsawayh [13].

From antiquity until the fall of the Roman Empire in Europe, the use of pearls was almost exclusively limited to ornamentation. However, following the 8th Calendar century, a new application emerged for pearls and other gemstones. During the period spanning the 9th through the 14th fourteenth Calendar centuries, the study of natural history in Europe received scant attention, save for its relevance to medicine and magic: two disciplines that were inextricably intertwined. Largely under the influence of Arab scholarship, the practice of medicine evolved to incorporate the prescription of exotic remedies treatments in which gemstones, and pearls in particular, played a prominent role. Indeed, the belief in the therapeutic efficacy of these gems was held with a conviction just as profound as the belief in the influence of celestial bodies. For this purpose, a great demand arose for pearls, which seem to have been prescribed for almost every ailment.

Due to their low cost, small pearls (seed pearls) were primarily used, although those who could afford them preferred larger sizes. While many of these "medicinal pearls" were imported from the East, most were harvested from local streams in Northern Europe and the British Isles [31].

## 14. Conclusion

Based on the in-depth analysis of this study, the following scientific conclusions can be drawn:

1. The study uncovers the phenomenon of the "erroneous circular reference" within Arabic scientific literature regarding the genesis of pearls, specifically, the persistent yet false attribution of the "Rain Theory" to Aristotle via a spurious text dating back to the 9<sup>th</sup> Calendar century, which served to entrench this myth as an indisputable cosmic truth.
2. There are two parallel positions within Arabic scientific discourse: the position of "textual veneration" exemplified by Al-Tifāshī, al-Qibjāqī, and others which sought to legitimize superstition through philosophical validation; and the position of "pure empirical observation" embodied by Al-Birūnī and, subsequently, Ibn Māsawayh which eschewed speculative explanations of origin in favor of focusing on physical and taxonomic properties.
3. Yahya Ibn Māsawayh's pioneered establishing the first geopolitical atlas of pearl-diving grounds, which is a work that included the earliest model for sustainable marine resource management through his documentation of the "fallowing" system; a practice based on cyclical pauses in diving operations designed to ensure the replenishment of pearl stocks.

Ibn Māsawayh's was the first to formulate a morpho-economic classification system for pearls; one that correlated a pearl's geometric sha.

## References

- [1] A. Garboe, *Kulturhistoriske studier over ædelstene: Med særligt henblik paa det 17. aarhundrede*. København & Kristiania: Gyldendalske Boghandel–Nordisk Forlag, 1915.
- [2] J. Wood, *The pearl*. Syracuse, NY: H. J. Howe, 1924.
- [3] a.-S. Al-Jumaylī, *Al-Aḥjār al-karīmah: Dirāsah tārikhiyah jughrāfiyah jiyūlūjīyah dūniyah*. Cairo: Maktabat Madbūlī, 1999.
- [4] M. T. Houtsma, *Al-Lu'lu'.* " In *Mūjaz Dā'irat al-Ma'ārif al-Islāmīyah*. Sharjah: Markaz al-Ibdā' al-Fikrī, 1998.
- [5] I. A. H. Hamīd, *Al-Aḥjār al-Karīmah fī Bilād al-Rāfidayn*. Duhok: Dar Al-Mashriq, 2013.
- [6] E. H. Kraus and C. B. Slawson, *Gems and gem materials*, 5th ed. New York: McGraw-Hill Book Company, Inc, 1947.
- [7] E. H. Schafer, *Durraq Samarqand al-dhahabi: Dirāsah fī gharā'ib 'ahd Tānj (S. al-Shāhid, Trans.)*. Abu Dhabi: Al-Majma' al-Thaqāfī, 2005.
- [8] E. R. Caley and J. F. C. Richards, *Theophrastus on stones: Introduction, greek text, English translation, and commentary contributions in physical science, No. 1*. Columbus, OH: Ohio State University Press, 1956.
- [9] Y. Ibn Māsawayh, *Kitāb al-Jawāhir wa-ṣifātihā (ed. 'Abd al-Salām Ra'ūf)*. Tehran: Mu'assasat al-Dirāsāt, 1968.
- [10] A. i. Y. Al-Tifāshī, *Azhār al-aḥkār fī jawāhir al-aḥjār (ed. Muḥammad Yūsuf Ḥasan & Maḥmūd Basyūnī Khafājī)*. Cairo: al-Hay'ah al-Miṣriyyah al-Āmmah lil-Kitāb, 2015.
- [11] B. Al-Qibjāqī, *Al-Qibjāqī, Baylaq ibn Muḥammad. Kanz al-tujjār fī ma'rifat al-aḥjār*. Manuscript. Paris: Bibliothèque, n.d.
- [12] a.-R. Sheikh, *Nukhbat al-dahr fī 'ajā'ib al-barr wa-al-baḥr*. Ed. A. F. von Mehren. Copenhagen: Royal Danish Academy of Sciences and Letters, n.d.
- [13] M. i. I. Ibn al-Akfānī, "Nukhab al-dhakhā'ir fī aḥwāl al-jawāhir (ed. Louis Cheikho)," *Al-Mashriq*, vol. 11, no. 10, p. 757, 1908.
- [14] A. i. 'Al-Qalqashandī, *Ṣubḥ al-a'shā fī ṣinā'at al-inshā*. Beirut: Dār al-Kutub al-Īlmiyyah, 1988.
- [15] M. i. A. Al-Ibshīhī, *Al-Mustaṭraf fī kull fann mustaṭraf*. Beirut: Ālam al-Kutub, 1998.
- [16] A. R. M. i. A. Al-Bīrūnī, *Al-Jamāhir fī ma'rifat al-jawāhir*. Hyderabad Deccan: Dā'irat al-Ma'ārif al-'Uthmāniyyah, 1939.
- [17] Kraus, Edward Henry, and Slawson, Chester Baker, *Gems and Gem Materials, 5th ed., 2nd impression*. New York: McGraw-Hill Book Company, 1947.
- [18] I. S. M. Hamoudi, "Precious stones in the first Abbasid Era (132–232 AH / 748–847 AD)," *Journal of the Faculty of Arts, Assiut University*, vol. 15, no. 41, pp. 297–298, 2012.
- [19] M. Dha'i, "The geological aspects of earth sciences in the Arab heritage," 1994.
- [20] A. Al-Sukari, *Al-'Arab wa-'ulūm al-arḍ*. Alexandria, Egypt: Manshūrāt Mansha'at al-Ma'ārif, 1973.
- [21] J. W. Hyde, *History of trade in the near east in the middle ages, Vol. 1, translated by Ahmed Muhammad Rida*. Cairo: General Egyptian Book Organization, 1985-1994.
- [22] A. M. Al-Tha'ālibī, *Laṭā'if al-Ma'ārif*, Edited by B. De Jong. Leiden: Brill, 1867.
- [23] J. Alī, *Al-Mufaṣṣal fī Tārikh al-'Arab Qabl al-Islām*, 4th ed. Beirut: Dar al-Saqi, 2001.
- [24] M. A. a. Ṭalas, *Tārikh al-Ummah al-'Arabiyyah*. Cairo: Hindawi Foundation, 2020.
- [25] A. Lucas, "Al-Mawādd wa-al-Ṣinā'āt 'inda al-Miṣriyyīn al-Qudamā', translated by Zaki Iskandar and Muḥammad Zakariyyā Ghunaym, Dar al-Kitāb al-Miṣrī, Cairo, p. 643," n.d.
- [26] S. Ḥasan, *Mawsū'at Miṣr al-Qadīmah*, 2nd ed. Cairo: Hindāwi Foundation, 2019.
- [27] A. I. a.-J. Al-Qayrawānī, *Al-I'timād fī al-adwiyah al-mufradah (E. al-Qash, Ed., pp. 279–280)*. Beirut, Lebanon: Sharikat al-Matbū'āt lil-Tawzī' wa-al-Nashr, 1999.
- [28] Al-Abshīhī, *Al-Ibshīhī, Muḥammad ibn Aḥmad. al-Mustaṭraf fī kull fann mustaṭraf*. Beirut: Ālam al-Kutub, n.d.
- [29] Anonymous Author, *Anonymous author. Risālah fī khawāṣṣ al-jawāhir wa-al-ma'daniyyāt. Manuscript* Tokyo: Institute for Advanced Studies on Asia (University of Tokyo), MS no. 133, fol. 79, n.d.
- [30] A. B. M. i. a.-'. Al-Khwārizmī, *Mufīd al-'ulūm wa-mubīd al-humūm*. Beirut, Lebanon: Al-Maktabah al-'Asriyyah, 1997.
- [31] G. F. Kunz and C. H. Stevenson, *The book of the pearl: The history, art, science, and industry of the queen of gems*. New York: The Century Co, 1908.