THE SOCIAL STRUCTURE OF ISLAM

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BY

REUBEN LEVY

Professor of Persian in the University of Cambridge

HISTORICAL RESEARCH INSTITUTE,

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In part their feebleness may have been due to poor leadership. Under the efficient generalship of Muwaffaq and his son Abu'l-'Abbās well-equipped forces of them were effective against the Zanj rebels in difficult territory in the southern Iraq marshes, and they undertook the heavy task, when labourers were not available, of undermining the walls of besieged towns with no more than their ordinary weapons.[1]

To maintain these standing forces, in the days when the central authority was strong and taxes flowed into the treasury, stipends and allowances were as a rule drawn from it, although in special cases military fiefs might be granted instead or in addition. Manṣūr is said to have given to the garrison at Maṣṣīṣa (Mopsuestia) grants of land over and above their stipends, but his successor Mahdī put a stop to the practice.[2] In later times, when the treasury was unable to meet the demands for pay, lands in the provinces were assigned to the chiefs of the "Turkish" guards on condition that they kept order and remitted certain annual sums to the capital. A well-known instance of this arrangement is that in which Bāyakbāk (Bābakyāl) received a large tract of Egypt as his fief. He himself remained at Baghdad, leaving the estates to be managed by agents, one of whom was the famous Aḥmad ibn Ṭūlūn. After the death of his master, who was killed by command of the Caliph Muhtadī, Aḥmad continued in control of the Egyptian estates and succeeded finally in making himself the independent ruler of the country.[3]

It was the Seljūqs later, it may here be added, who made the greatest use of the system of grants. An important instance is the grant by the Seljūq Sulṭān Maḥmūd in 515/1121 of the town of Mosul and the adjoining lands to the Amīr Āqsunqur for his services in war.[4] The Seljūqs were not wealthy and at times were hard put to it to pay their men,[5] but they introduced certain safeguards for the protection of the peasants, from whom only specified sums might be exacted and whose wives and children were not, under penalty, to be molested.[6]

[1] Ibn al-Athīr, VII, 234 ff.
[2] Balādhurī, pp. 165 f.
[3] Ibn al-Athīr, VII, 126 f. Cf. *ibid.* VII, 89 and see further (for the case of Ahmad b. Sa'lūk in Rayy), Ibn Khaldūn, *Kitāb al-'Ibar* (Būlāq, A.H. 1284), III, 370.
[4] Ibn al-Athīr, X, 1415.
[5] Rāwandī, *Rāḥat al-ṣudūr*, ed. Md. Iqbāl (London, 1921), p. 127.
[6] Niẓām al-Mulk, *Siyāsat-nāma*, ed. C. Schefer (Paris, 1891), p. 28.

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Owing to the abuses of the system, it fell into great disrepute amongst the common soldiery and the peasants, for although the chiefs managed their properties well the common run of the men had no notion of agriculture, and by neglecting watercourses and paths they soon reduced their land to ruin and were compelled to demand other forms of compensation for their services.[1]

The "Turks" were finally ousted from their position by the Buwayhids, who, being themselves well organized, were able to disperse the Baghdad *jund*, at that time and for long afterwards no more than a leaderless rabble of brigands preying on the citizens.[2]

For practical purposes any central army which could be called upon to fight for Islam, as represented by the Muslim empire under the Caliphate, disappeared with the domination of the Turkish bodyguard. Yet there remained, it must be remembered, numbers of men inspired by their faith who would come to its aid when danger threatened. Mention has been made of the volunteers who fought even under the Umayyads, who were regarded as a worldly and irreligious dynasty. Many more gathered about the Abbasid standards when there was need to help in the defence of Muslim territory and in the raids into the territory of the Byzantines in Asia Minor.[3] When the enemy in his turn attacked the frontier cities (*thughūr*) of Islam in Syria, Mesopotamia and elsewhere, it was not the army of the Caliph but the local inhabitants to a man who gave their services, "save those who had neither horse nor weapons".[4] Furthermore, in the days when the Caliph was unwilling or unable (as, for example, in the case of Musta'īn) to take action against the infidel, Muslims living far from the scene of aggression would send assistance in men and materials to their co-religionists who were defending the frontiers.[5]

If it was necessary to fight a rebel or a heretic nearer home, the Caliph or the officer charged by him with command of a punitive

[1] Ibn al-Athir, VIII, 342. This refers to the Buwayhid Mu'izz al-Dawla, who made grants of land in 334/945–6, when he was either unwilling or unable to pay his troops otherwise. But long before then there had been dissatisfaction with the system. (Cf. Tabari, III, 1799.)

[2] Ibn al-Athir (363/973–4), VIII, 474 ff., 483; (417/1026), IX, 248, 254 ff.

[3] Cf. Tabari, III, 709.

[4] *Ibid.* III, 1235. Cf. Ibn al-Athir, VIII, 172 ff., 399, 460.

[5] Cf. Ibn al-Athir, VII, 80.

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force, could often rely upon local aid, as when the Caliph Mu'tamid in 257/871, after a regular force under his chamberlain had been defeated,[1] sent Aḥmad al-Muwallid to Baṣra against the Zanj. There a great number of men "gathered about him",[2] presumably volunteers, whose lack of training and skill led to their being easily routed by a determined force more accustomed to fighting. A further disadvantage in the employment of the *mutaṭawwi'a* was that they were not altogether subject to the common discipline imposed by military exigencies, for if they followed their own feelings about coming, they also used their own judgment about departing. An occurrence of this nature under the Umayyads has already been described above. Another instance is given by Ṭabarī, who, in his account of the long fight against Bābak, the Khurramī heretic, says that when, one campaigning season, victory was seen to be impossible, the "volunteers" determined to return home.[3]

In the days when the power of the Caliph was supreme, with his authority and influence intact, the organization of the military side of the State possessed a considerable measure of efficiency. Nominally the central authority worked through the *Dīwān al-Jaysh* (Ministry of the Army) which was declared responsible for recruitment and pay of troops.[4] Actually the Caliph himself or his vizier were concerned with these matters, which were amongst the most important in the State. Military policy was decided in the last resort by the Caliph, and he was responsible for war and peace. To him personally, as has been seen, was attached a body of warriors who did duty as his bodyguard whether in war, which was the normal state, or peace, which was the period of the year when campaigning was not possible. When it was necessary to proceed against a powerful enemy, whether a foreign infidel or a rebellious vassal, the bodyguard was increased by the addition of men from the tribes. In the recruitment of them the chiefs performed an important office, for it was they who roused their tribes to war and it was about its own *ra'īs* that each tribe rallied, marched and fought.[5] Provision for war and general organization were as a rule left to the central authority.[6]

[1] Ibn al-Athīr, VII, 166. [2] *Ibid.* VII, 170. [3] Ṭabarī, III, 1214.
[4] See Māwardī, *Constitutiones Politicae*, ed. Enger (Bonn, 1853), pp. 351 ff.
[5] Cf. Ṭabarī, I, 2224, 2815 f., 2985, 3153 ff.; III, 843.
[6] Ibn al-Athīr, III, 242.

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The organization of the Buwayhids, who held the central authority in the eastern Caliphate after they had ousted the "Turkish" bodyguard, was definitely a military one, but not much is to be gleaned from the historians to throw light upon it. Thus many pages of his chronicle are filled by Ibn al-Athīr with the exploits of the Buwayhids, but he rarely gives details to explain either the organization of their military system or of their methods of war. It may be assumed that the Daylamite tribesmen fought under their Buwayhid chieftains on condition of receiving a share of the plunder gained, for, like other men of their kind, they rioted when their pay was not given them.[1] As the armies advanced, they were joined at various periods by men from the conquered territories, and by tribal chiefs and their retinues in search of gain, but volunteers had no significant place in their system.[2]

The Buwayhids in their turn were ousted by the Seljūqs, of whom considerably more is known. They are reported as having, in 420/1029, been engaged in battle with Maḥmūd of Ghazna, who attempted to drive them out of his territories which they had invaded, and attacked them in the open country outside Bukhārā. They then numbered two thousand tents and were making for Iṣfahān. Another branch of these Ghuzz Turks, under Tughril Beg, Dā'ūd and Yabghū, were then in Transoxiana and were moving south and west.[3] This branch must even then have been very strong numerically, for there is a legend to the effect that when Maḥmūd heard of them he entered into negotiations with "the four sons of Seljūq ibn Luqmān", and to gain some idea of their resources pretended to them that he might require their help for his raids into India and asked what would be forthcoming. The Seljūq representative carried a bow and had two arrows stuck in his girdle. One of them he handed to Maḥmūd, saying: "When you have need of help send this to my host and a force of a hundred thousand mounted men will come to your assistance." Maḥmūd then asked what would happen if he needed further auxiliaries and was told to send the second arrow, when he would receive a further fifty thousand horsemen. "What if they are still

[1] Ibn al-Athīr, VIII, 342.

[2] Cf. *ibid.* VIII, 520, where a number of the allies of 'Aḍud al-Dawla are mentioned.

[3] *Ibid.* IX, 266.

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insufficient?" persisted Maḥmūd. The Seljūq general in reply handed over the bow and said: "Send this as a token to Turkistān, and if you require two hundred thousand men you shall have them."[1]

For that early stage of their career the figures given are doubtless exaggerated, but once their conquests began in earnest the Seljūq armies obtained accretions of men from the various tribes, both kindred and foreign, whom they subjugated or with whom they allied themselves. Thus, the princes who submitted to Tughril Beg in Ādharbayjān and elsewhere offered him the services of their *junds*,[2] and some years later, Tughtagīn, a Turkoman amīr who had been engaged in raiding Byzantine territory, persuaded the Seljūq Sulṭān Alp Arslān to join forces with him. Alp Arslān subjugated a number of cities in Asia Minor and their inhabitants became part of his *jund* and his following.[3] Similarly, when, in the decisive battle of Manzikert (463/1071), which brought the Eastern Roman domination in Asia Minor to an end, the Byzantines were defeated and their emperor Romanus Diogenes was captured, one of the conditions of peace was that a specified number of troops should be sent to the conqueror on his demand.[4]

The admixture of foreign soldiery with the Seljūq warriors seems to have formed part of a settled policy, for Niẓām al-Mulk, the famous minister of three successive sulṭāns, in his *Siyāsat-nāma* ("Treatise on Government") declares that the army ought to be composed of troops of different nationalities to prevent any danger from concerted rebellion. Thus, he suggested, the guard at the palace should consist of two thousand Daylamīs and Khurāsānīs, with sections composed of Georgians and men of Fārs.[5] Some part of Niẓām al-Mulk's theory was based upon the practice of Maḥmūd of Ghazna, who employed in his army men of numerous different peoples, such as Turks, Khurāsānīs, Arabs, Hindus, Daylamīs and others. On the march, each "nation" was warned of the number of men required from it for guard-duty at night. The station of each was precisely allotted, and through fear of report by the others no group dared move from its appointed

[1] Rāwandī, *Rāḥat al-ṣudūr*, p. 89.
[2] Cf. Ibn al-Athīr (A.H. 446), IX, 410 f.
[3] *Ibid.*, X, 25.
[4] Ibn al-Athīr X, 45.
[5] *Siyāsat-nāma*, ed. Schefer, pp. 92 f.

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place until relieved at dawn. If, during the daytime, there was a battle, each group fought as a separate unit.[1]

Since the Seljūq State was conducted upon a military basis, it need occasion no surprise when Niẓām al-Mulk mentions four hundred thousand troopers as the strength of his master's army and declares that a reduction to seventy thousand, which a courtier had proposed to the sovereign during a spell of peace, would mean ruin to the State, while an increase to seven hundred thousand would mean its greatly heightened prosperity.[2]

Not all these numbers of men were ever employed together in the same quarter. Forty-six thousand troopers are mentioned as having formed the army of the Sulṭān Malikshāh against the Ghaznawids on one occasion[3] and at the battle of Manzikert the Sulṭān Alp Arslān was able to muster no more than fifteen thousand troopers, although the enemy were said to have been two hundred thousand strong.[4]

The Caliph, like the Prophet, was always, if not actually then in theory, in supreme command of the forces of Islam. To him belonged the authority to use troops and the power to dispose as he wished of all military equipment and supplies. When Hārūn al-Rashīd determined to make his son Ma'mūn heir to the throne he was in Khurāsān, where he summoned the qāḍīs and men of standing and made them bear witness that everything in his army, including money, treasure, arms, horses and other equipment, was in the hands of his son Ma'mūn, and of no one else.[5] Hārūn himself was more than once in command of armies against the Byzantines and even as a child he had been in nominal command under the tutelage of a member of the Barmecide family.

Next to the Prophet or the Caliph came the generals appointed by him. Sometimes the Caliph gave command to his own sons, but more often the commanders were men who had had experience of warfare, and they in their turn appointed their own officers, for whom the first qualification required, except in special circumstances,[6] was military skill. Ṭāriq ibn Ziyād, who conquered Andalusia, was a freedman,[7] and at a later time even slaves could

[1] *Siyāsat-nāma*, ed. Schefer, pp. 92 f.
[2] *Ibid.* p. 144.
[3] Rāwandī, *Rāḥat al-ṣudūr*, p. 131.
[4] Ibn al-Athīr, x, 44 f.
[5] See Ṭabarī, II, 510[1]. Dīnawarī, *Akhbār al-ṭiwāl*, p. 118.
[6] *Ibid.* (A.H. 189), VI, 130.
[7] *Ibid.* II, 1235.

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be given command, although more often they seized it.[1] Under the commander-in-chief, normally, the tribal chiefs led their men in battle, but he might appoint competent substitutes if they themselves were for any reason absent.[2] After the death of the Prophet, the old feelings of tribal independence and equality were amongst some communities temporarily revived. Thus, the tribal chiefs, at the battle of the Yarmūk, when there was confusion about the command of the Muslim forces, were prepared each independently to go into battle with their own men, without any consultation or co-operation with one another.[3]

The institution of a system of military gradation is ascribed to Omar, who went on the basis of a practice of Muhammad. It is said to have originated when Omar wrote to the commander of the force advancing into Persia, who was then at Qādisīya, ordering him to divide his army into ten, to appoint *'arīfs* and amīrs and to arrange the whole force into *ta'bīya*, which is a military formation perhaps best described as parade order.[4] He was further commanded that the whole army was to be divided into tens and that each ten (*'irāfa*) was to be in charge of a man of their own people and known as an *'arīf*.[5]

In order of precedence the amīr or commander-in-chief came first; the commanders of the divisions of the *ta'bīya* held rank next to the amīr, next to them came the commanders of the tenths, then the standard-bearers, who would appear to have held high rank,[6] and lastly the tribal chiefs. There were also separate commanders for the infantry and the cavalry, but their position in the list is not specified.[7]

[1] In the fight between the "Turkish" chiefs Bajkam and al-Barīdī, the latter gave command of his army to his slave Abu Ja'far. (Ibn al-Athīr, VIII, 257.) Aḥmad ibn Ṭūlūn, who seized the reins of government in Egypt, was a slave, and the case of the Mamlūks in that country is well known.

[2] Cf. Ṭabarī, I, 2116.

[3] *Ibid.* I, 2091 f. Cf. Dozy, *Supplément*, s.v. *sanada* (VI).

[4] See below, p. 427.

[5] The "ten" (*'irāfa*) was regarded as an institution of the Prophet's (Ṭabarī, I, 2225). It was considered under Omar as a convenient group for purposes of the distribution of pay. (See above, p. 412.)

[6] Ṭabarī, I, 1616. Khālid ibn Walīd made himself an amīr although he had not been appointed, when he took charge of one of the Prophet's standards.

[7] A similar system was employed by the rabble army of the Caliph Amīn at the siege of Baghdad. Each group of ten was commanded by an *'arīf*, ten *'arīfs* by a *qā'id* and ten *qā'ids* by an amīr (Mas'ūdī, *Murūj al-dhahab*, VI, 452).

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Apart from the fighting officers there were also appointed to the force physicians, a qāḍī, who was in charge of the booty before it was distributed and saw to its equitable division, a *dā'iya* or advocate to put forward the claims of the men, a *rā'id*, whose duty it was to find camp-sites, an interpreter and, lastly, a scribe.[1]

The general organization for war seldom included any specific training of the army. However, most of the operations in which the men were engaged were little more than raids on a large scale, and in the art of raiding the tribesmen required little instruction. The Caliph's personal bodyguard which formed the backbone of the fighting service was in a different position. It was reviewed and tested frequently, and one Caliph at least, Mu'taḍid, carried out these duties in person. At certain periods he mustered his corps on the parade ground of the capital, where a target was set up and each man's skill in archery and horsemanship was tested. The results (good, medium or bad) were entered into a register, and upon them depended the nature of the duties assigned to each man.[2]

The recognized military formation, whether on parade, on the march, or in battle, was the *ta'bīya*. In it the army was divided into five main divisions,[3] namely centre, right and left wings, van (*muqaddama*) and rear-guard (*sāqa*). The men forming each division consisted of men of the same tribes or otherwise known to each other. The centre was the position of the amīr and his retinue, and in the wings on either side were subordinate commanders. Separate from them and in front of the centre went the vanguard with its own commander and flag. The *sāqa* acted as rear-guard and also had charge of baggage, supplies, arms and heavy siege engines.[4] In addition there were light-armed troops separate (*mujarrada*) from the rest of the formation and also bodies of scouts or advanced guards (*ṭalā'i'*). The various parts of the formation might be close together or at a distance from one another, as circumstances demanded.[5]

[1] Ṭabarī, I, 2223 ff.

[2] Al-Ṣābī, *Kitāb al-Wuzarā*, p. 13.

[3] Whence an army is sometimes in Arabic called *khamīs*, "Five". Ibn Khaldūn (*Prolégomènes*, ed. Quatremère, II, 67) assumes that this formation was learnt from the Greeks and Persians. (Cf. Ṭabarī, I, 2266, for Persian formation.)

[4] Ṭabarī, III, 1238; *Fragmenta Hist. Arab.*, II, 485 f.

[5] Ibn Khaldūn, *loc. cit.*

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The "five" formation was in use as early as the Prophet's own time, e.g., at the battles of Badr and Mu'ta,[1] and to its invention and introduction has been attributed much of his success against opponents who were still using the old irregular methods of attack. With such variations as shall be noted, it continued for centuries to be the recognized formation in Islam on the road or the parade-ground, although it appears in the actual conflict to have kept no more than its name.

The ordinary method of fighting in vogue in Arabia at the beginning of the Prophet's career was that of the raid, in which a sudden charge was followed by prompt retreat and a sudden return to the onslaught.[2] This method was retained by the Prophet's earliest converts when they went out against the Quraysh caravans. There was at most an interchange of arrow shots and the men returned without achieving their object and without doing or receiving much harm.[3] By the time of the battle of Badr (A.H. 2) the Prophet had acquired some military sense[4] and then introduced the new formation of the *ta'bīya* for the first time, with great success. He had very few more than three hundred men, of whom only one was mounted.[5] He arranged them in straight, regular ranks, which he put in order himself, walking along the ranks with an arrow in order to push back any man who was out of line with the rest.[6] Behind the fighting line was the *sāqa*, in charge of the baggage and transport-animals.[7] A verse of the Koran (61[4]), if it may be taken literally, would seem to imply that the Prophet intended this new formation to be permanently adopted, and colour is lent to the possibility by the fact that in 145/762 when the Caliph Manṣūr sent 'Īsā ibn Mūsā to fight the 'Alid pretender Ibrahīm ibn 'Abd-allāh (who claimed to be of the kin of the Prophet), the 'Alid was advised to meet the onslaught with his men in a broken line of cohorts rather than in the old formation. He refused, however; saying that the change was an

[1] Ṭabarī, 1, 1299, 1614.

[2] The method known as *karr u farr*, literally "return and flight". (Cf. Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, II, 66.)

[3] See Ṭabarī, 1, 1365–7.

[4] His strategy even at Badr was not approved by those of more military experience. (Cf. *ibid.* 1, 1309.)

[5] Ṭabarī, 1, 1297.

[6] Ibn Hishām, ed. Wuestenfeld, 1, p. 444; Ṭabarī, 1, 1319.

[7] Ibn Hishām, 1, 433.

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unlawful innovation in Islam and quoting the verse of the Koran cited above.[1]

In spite of the permanence thus implied, changes were inevitable after the Muslims had had experience with enemies more accustomed than themselves to pitched battles and with the improvement in their own means of warfare.

An important change was brought about by the introduction of horses. At Badr there had been only one mounted man and the Prophet was compelled to wait for the attacks of the enemy, although he followed sound military practice when he kept an unbroken wall of infantry to receive the enemy's cavalry. On that occasion he attended the battle in a litter.[2]

At the battle of the Yarmūk, less than ten years later, the Muslim army faced the Byzantines with forty-six thousand men, all mounted.[3] Nearer home, unmounted men were not entirely discarded, and at the battle of Ṣiffīn there were both arms, under separate commanders, on the side both of 'Ali and of Mu'āwiya. The value of the infantry and cavalry as a support to each other was clearly recognized by the Umayyads, who used them both when they could, as in 65/684–5 against the Shī'ite rebels of Kūfa under Sulaymān ibn Ṣurd, who demanded vengeance for the death of Ḥusayn.[4] Infantry were also used in support of cavalry in the penetration of Persia by Qutayba, who, meeting with resistance before Bukhārā, laid siege to the city. A sally by the Turkoman horse was driven back, but they rallied on some raised ground across the river which had to be crossed and they were able to impede Qutayba's advance. After a good deal of hesitation on the part of the tribesmen, the Muslim cavalry swam over, leaving a small force of infantry to cross by a hastily constructed bridge. While the cavalry created a diversion the infantry attacked and the Turkomans were put to flight.[5]

With the Abbasids, infantry came to be more rarely used. The effective forces, except in the campaigns against the Zanj in the marshes of lower Iraq, were all cavalry,[6] and if it was necessary to take infantry they were not seldom mounted behind the cavalry.

[1] Ṭabarī, III, 312. [2] *Ibid.* I, 1318. [3] *Ibid.* I, 2091, 2096.
[4] Cf. *ibid.* II, 554. [5] *Ibid.* II, 1201.
[6] Some others were present. A prisoner taken at the battle of the Zāb said he was merely a slave belonging to one of the soldiers (Ṭabarī, III, 39).

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At the battle of the Zāb, in which the Umayyads were finally routed, the Abbasid cavalry were ordered to dismount and meet the enemy's charge, kneeling with their lances held out in front of them.[1] Where the country was unfavourable for the movement of horses, the cavalry had to fight on foot.[2]

Another important change in the established formation was introduced at the battle of the Yarmūk, when the Byzantine army advanced in a line of squadrons. This so impressed the Arabs that at the suggestion of their commander, Khālid ibn Walīd, they proceeded immediately to dispose their own force in the same manner. Centre, right and left wings consequently were divided up into a number of squadrons (estimated at thirty-six or forty), each composed of men of the same tribe and under its own leader.[3] This is the first occasion on which the *karādīs* (singular *kardūs*) in the Muslim army are mentioned, but Ṭabarī in a later passage[4] declares that it was Marwān II, the last of the Umayyad Caliphs, who abolished the unbroken line-formation and introduced instead that consisting of a number of the compact bodies of troops known as *karādīs*.[5] This would imply that the *kardūs* was a temporary expedient at the Yarmūk and that for a time there was a reversion to the traditional practice of putting the men into line of battle consisting of an elongated and unbroken oblong. However that may be, it appears that the *kardūs* was simply a detachment or subsection of the larger divisions, for the arrangement into centre and wings was maintained, each being divided into a number of *karādīs*, as in the attack on Amorium under Mu'taṣim.[6] In that campaign there was a distance of two parasangs between the centre and the wings, and each of these divisions was itself divided into right and left wings.[7] As a general rule, however, the divisions remained in close contact and if one of them was being hard pressed, men from the others might easily be detached so as to go to its help.[8]

In early times a common preliminary to the battle, in continuance of the pre-Muslim custom, was to harangue the men and to

[1] Ṭabarī, III, 40.
[2] Ibn al-Athīr, VII, 240.
[3] Ṭabarī, I, 2091 ff.
[4] *Ibid.* II, 1941.
[5] It is upon this passage that the statement of Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, II, 81, appears to be based.
[6] Cf., for example, Ṭabarī, III, 1247[12].
[7] *Ibid.* III, 1244.
[8] Cf. *Fragmenta Hist. Arab.*, I, 218, and Ibn al-Athīr, XII, 23 f.

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rouse their martial ardour by the recital of verses reminding them of the exploits of their kinsmen. "You are poets and orators and Arab knights", said the commander at the battle of Qādisīya to his lieutenants: "Go amongst the tribes and the regiments [banners] and stir the men to war."[1]

Another frequent preliminary to the general onslaught was the fight between champions from either side. Thus at Badr, before the order came to attack, the herald of the still pagan Quraysh challenged the Muslims to send out men for single combat. Three citizens of Medina came out in reply to the challenge, but the Quraysh would have nothing to do with them, demanding men who were the equal of themselves in birth and prowess. The Prophet accordingly nominated three of his companions to go out, and they were accepted. Two of the Muslims killed their opponents outright, the third had some difficulty and his comrades rushed to his aid, so that the battle began in disorder.[2] A similar method of beginning by single combat between picked warriors of either side was practised even in foreign campaigns. In 115/733, in a summer raid against the Byzantines, a young Greek who had slain five men was finally opposed by the Muslim commander, who went forward himself and having killed the youth called on his own men to charge.[3] The most common way, perhaps, in which battles began was in engagements of outposts or advanced guards who met each other before the main bodies came up. An instance is recorded where the Seljūq forces first met those of the Ghaznawids in this fashion.[4]

Tactics in the battle naturally varied with circumstances. At Badr, the Prophet commanded his men that they were not to attack until he gave the order, though they might beat off with arrows such of the enemy as came inconveniently close.[5]

At Qādisīya the Persians were in thirteen ranks, one behind the other, while the Arabs were much inferior both in numbers and equipment. Their three ranks suffered much from the Persian arrows, against which their only defence was a barrier of palm-branches stuck upright into their baggage, the leather thongs from

[1] Dinawarī, *Akhbār al-ṭiwāl*, p. 128.
[2] Ṭabarī, 1, 1317 ff.
[3] *Fragmenta Hist. Arab.*, 1, 91.
[4] Cf. Bayhaqī, *Ta'rikh-i Mas'ūdī*, ed. Morley, p. 714.
[5] Ṭabarī, I, 1318.

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which they employed to bind round their heads in substitution for helmets.[1] Their own arrows were lacking both in quantity and quality and the Persian jibe at the thin Arab arrows as "spindles" has been preserved.[2] But the day was won in spite of this ill equipment. The Muslims stood firm until the order was given to charge, and then came on with their lances until they were in amongst the Persians. They then threw away the more unwieldy weapons and used their swords to good effect.[3]

When, at Ṣiffīn, 'Alī fought Mu'āwiya, he put his infantry into a single *ṣaff*, i.e., the unbroken line of the Prophet's devising, with men in armour in the front rank.[4] His instructions for the attack were that the line was to advance until the men's lances were almost at the chests of the Umayyad troops, when they were to halt for further orders.[5] In the charge, he told his men, they were to lean forward over their spears for better effect.[6] His cavalry were formed into *karādīs* and were armed with bows and swords, but once they got in amongst the enemy after their charge the bows were useless and the men took to their swords.[7]

The Umayyad line of battle, as illustrated in the conflict with Shabīb the Khāriji heretic, had the usual division into centre and wings, but the whole line was formed of three ranks, of which the first consisted of infantry armed with swords and under separate command from the rest, the second of mounted men with lances and the third of archers, presumably mounted also. The line was subdivided into regiments (*rāyāt*, literally "banners") under subordinate commanders, but it is not clear whether each *rāya* was composed of all arms or contained only men from a single arm.[8]

No variation of the traditional order of battle is reported from early Abbasid times. Yet it was not always rigidly maintained. In a battle between two Abbasid forces, those of Ma'mūn and Amīn, in Khurāsān in 195/810, their respective generals Ṭāhir and 'Alī ibn 'Isā disposed their troops in different formations. Alī ibn Isā had the usual prime distribution into centre and wings, but decided that his men were too few to advance in an unbroken line. He accordingly subdivided them under banners, a thousand men to each, and attacked with the wings, sending forward the

[1] Ṭabari, I, 2353 f. [2] *Ibid.* I, 2236; Balādhurī, *Futūḥ*, p. 260.
[3] Dinawari, *ibid.* [4] Ṭabari, I, 3290.
[5] Mas'ūdi, *Murūj al-dhahab*, IV, 374.
[6] Ṭabari, *ibid.* [7] Mas'ūdi, *ibid.* IV, 376. [8] Ṭabarī, II, 950.

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rāyāt one at a time at intervals of a furlong,[1] the men in armour in the van of each, with the order to the commanders that they were to attack in rotation, retire, and attack again when they were rested. 'Alī himself remained in the centre with his guards and the "notables". Ṭāhir, on the other hand, arranged his men in smaller divisions (*katā'ib* and *karādīs*), and these were unable to withstand the attack of the heavier bodies. The day would have gone against him if he had not rallied his men in an interval and launched a surprise attack on 'Alī's centre, which had remained in position and which fled before the sudden onslaught.[2]

A variation on the usual order of battle is illustrated by the formation used in 517/1123 by Dubays, the rebellious vassal of the Caliph Mustarshid, in opposing the government force sent against him. He put his whole army into one unbroken line, with centre and wings under separate commanders as usual. His infantry, however, was placed in front of his cavalry, which being thus immobilized was rendered useless, and he was defeated.[3]

The tactics of the Seljūqs was conditioned by their being nearly all mounted men. Their line of battle was in the normal centre and wings order, but it was much deeper than under the Abbasids, so that in each division there was more than one subordinate commander. In the battle between Sulṭān Mas'ūd and his uncle Sulṭān Sanjar near Dīnawar in 526/1131, Sanjar remained in the centre with the flower of his army, while on each wing the men were in charge of three subordinate commanders and thrown out in front of the centre was a line of elephants. Mas'ūd's formation was similar, although he had but two commanders on each wing.[4]

The "five" formation was used within the boundaries of the Eastern Caliphate by so great a warrior as Maḥmūd of Ghazna, but he was able to make it more effective by the use of elephants in the battle. In a letter to the Caliph al-Qādir reporting how he conquered Khurāsān and defeated the Sāmānids he says that he gave command of the right to one of his brothers. In it were ten thousand men—infantry—and thirty elephants, while on the left wing were twelve thousand cavalry and forty elephants. Maḥmūd himself was in the centre with seventy elephants and twenty

[1] Ibn al-Athir, VI, 168, calls it a bowshot.
[2] Ṭabari, III, 823; Ibn al-Athir, *ibid.*
[3] Ibn al-Athir (A.H. 517), X, 428 f.
[4] *Ibid.* X, 476.

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thousand cavalry, equipped with swords and lances, shields and armour.[1]

Concerning the theory of battle, the Spanish essayist, Abu Bakr Ṭurṭūshī (i.e. of Tortosa), who died in 520/1120, has something to say in his work entitled *Sirāj al-mulūk*.[2] According to him, the leader in battle must be a bold and courageous man, experienced in war and knowing the positions of the centre, right wing and left wing in battle.[3] As for the disposal of the force in battle, the author gives it as his opinion that the best order for the line is in three ranks. The first should be composed of infantry armed with good shields, long lances and sharply-pointed javelins; the (butts of the) lances to be fixed in the ground behind with the points inclined towards the enemy, while the men themselves kneel on the left knee with their shields upright in front of them. The second line should be composed of picked archers "whose arrows can pierce armour", and behind them again should come the cavalry. In the attack—it is presumed that the enemy move first—the infantry keep their position and formation, while they and the bowmen transfix the advancing enemy, the first with their javelins and the others with their arrows. When the enemy come close enough the lances are brought into use and as they scatter right and left the cavalry come forward and "obtain from them what God wills".[4]

In general the "five" formation was effective. Its danger lay in the difficulty of control if the force was large or too widely scattered, and especially so if the divisions lost sight of one another, as might happen during a dust-storm,[5] seeing that orders had to be sent by messenger or to be signalled by trumpets or flags.

It was the common practice that the signal for the attack was given by the waving of a flag or by trumpet blast or both.[6] Flags

[1] Al-Ṣābī, *Wuzarā*, p. 374. [2] Ed. Cairo, A.H. 1289. See *infra*, p. 456.

[3] *Op. cit.* p. 299.

[4] *Op. cit.* p. 308. The author implies that he has seen in action the formation he describes. [5] Cf. Bayhaqī, *Ta'rīkh-i Mas'ūd*, i, p. 717 *ad fin.*

[6] Balādhurī, *Futūḥ*, p. 303. At the battle of Nihāwand Nu'mān the 'āmil said: "I noticed that when the Prophet failed to give battle in the morning he would wait until the sun set and the wind blew." He added: "I shall now shake the standard I carry three times. At the first shake let each man perform his ablutions and satisfy his natural wants; at the second let each attend to his sword (or he may have said sandal-thong) and prepare himself. When the third shake comes, charge; and let no man heed his neighbour." Cf. Ibn al-Athīr, VII, 281.

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had another significance in Muslim warfare. Each tribe had its own and regarded it as the rallying centre in battle, for near it was the position of the commander.[1] An example is provided by an incident that occurred in one of the battles between the force of Saladin and Safadin (Sayf al-Dīn). The latter's general in the field had set up his standard in a low-lying part of the plain, where it was out of sight of the men engaged in the battle. At a crucial point in the fight the absence of the flag was noted and the rumour promptly spread that the commander had fled.[2]

The importance of the symbol may be gauged from the prominence given to the names of those who bore the Prophet's banner and that of the *Anṣār* at the battle of Badr,[3] also of the standard-bearers in other, later, engagements. The phrase used for sending out an expedition is "to bind on a banner",[4] and the granting of a banner was regarded as the sign of conferring command. When the Caliph Mahdī was in Khurāsān he was faced by a rebellion under the Persian chieftain Ustādhsīs. A certain Khāzim ibn Khuzayma offered to quell it, but only on condition that no flag should fly except his own or such as he had "tied on". When he received command he lowered the flags of all others of whom he disapproved.[5]

On the Abbasid military system in general some additional information is to be obtained from an important non-Muslim source, namely the *Tactica* of the Byzantine Emperor Leo VI ("The Wise"). Leo did not himself fight the Saracens and his information is not at first-hand, but he used for his work the materials provided by his father, the Emperor Basil, and by generals who had fought on the frontiers. The Byzantine emperor reigned from 886–912 and was a contemporary therefore of the Caliphs Mu'tamid, Muktafī and Muqtadir, under whom the Abbasid régime had begun its decline. But the old system was still in great part retained, having had a considerable measure of success under Mu'tamid, in particular when the royal forces in command of Muwaffaq, the Caliph's brother, operated against the Zanj rebels in southern Iraq.

[1] Cf., for example, Tabarī, II, 498: "You cannot dispense with an amir to whom you may have recourse and a flag about which you may rally."

[2] Ibn al-Athīr, XI, 283. [3] Tabarī, I, 1297. [4] *Ibid.* I. 2080.

[5] *Ibid.* III, 355. A distinction is here made between *liwā*, "banner" and *'alam*, which is normally translated "standard".

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The *Tactica*, amongst much else that is of interest, shows what importance the Saracens attached to speed and mobility. Their infantry were carried on horseback or rode behind the cavalrymen.[1] It was effective tactics, therefore, to attack the horses as well as the men, since it decreased their mobility, and the best defence against Saracens and Turks was an abundance of bows and arrows "for their whole hope of victory is based on arrows".[2] For transport they used camels, horses, asses and mules, and in battle they clanged cymbals and used their camels in order to terrify the horses of the enemy. The camels and all the other sumpter-beasts had a further use in battle, for they were so placed in the midst of the troops as to give the appearance of large and important forces.[3] In front of the troops was thrown out a screen of Ethiopians, whose effect upon the enemy, although they were lightly-armed and unprotected, was considerable. The knights themselves were armed with bows and arrows, two-edged swords (*spatha*), lances, shields and axes. They bore as armour helmets, breastplates, arm-pieces and greaves and had other equipment, too, like that of the Romans.[4]

In battle they never broke their formation (*acies*) either in attack or defence. If, however, it was broken, it was not easily reconstituted.[5] This formation, which they kept both on the march and when at close quarters with the enemy, was an elongated, solid oblong, which was very safe and difficult to counter in the attack.[6] They met the enemy's charges steadily and quietly, waiting till they saw he was exhausted before themselves attacking. This they did also in their naval battles.[7]

Leo, or his informants, very well understood Arab mentality. "They are bold," he says, "when hopeful of victory, but easily frightened if they are in despair of it."[8] They were always in fear of night attacks, especially in foreign territory, and took great precautions against them. Guards were on duty all night, or else the camp was carefully fortified so as not to be taken by surprise.[9]

Much of what Leo says is borne out, it will have been seen, by what can be derived from the Muslim historians themselves and his general statements can be further supplemented from them.

[1] *Tactica* (in Migne, *Patrologia Graeca*, vol. 107), § 115.
[2] *Ibid.* §§ 22 f. [3] *Ibid.* §§ 112 f. [4] *Ibid.* §§ 114 f.
[5] *Ibid.* §§ 116 f. [6] *Ibid.* §§ 118 f. [7] *Ibid.* §§ 121 f.
[8] *Ibid.* § 117. [9] *Ibid.* § 117.

Let us now turn to other aspects of Muslim military organization. It will have been gathered that in the earliest part of their career the fighting forces of Islam were as ill equipped with arms as with men. Contact with Greeks and Persians, however, taught them much. After the first stages the chief weapons of the infantry were spears or lances and swords, while the mounted men had bows and either lances or swords. Slings are sometimes mentioned but not as part of the regular equipment of the warrior.[1] For protection each man wore a helmet with a flap at the back[2] and a breastplate[3] and carried a round shield.[4] On distant expeditions also a man carried needles and thread, an awl, scissors etc. as part of his kit.[5] In battle, commanders and others of high rank wore coats of mail which proved on occasion too heavy for the wearer.[6] A fully-equipped man might wear two breastplates and a full suit of armour (*tannūr*, literally "oven").[7] In single combat the champion carried a sword and shield only[8]; and in general, desperate fights at close quarters meant that bows and arrows were discarded in favour of the sword or (?) dagger (*dabbūs*).[9] Cavalry in a charge used lances and swords.[10]

Although the invention of gunpowder is popularly ascribed to the "Arabs" there appears to be no record of the use of fire-arms by Muslims for some time after the adoption of the new weapons in the west.

Defence of its frontiers was one of the most urgent and obvious duties of the early empire of Islam. On the Byzantine borders in particular, where attacks were most commonly to be countered, a series of fortresses or strong points (*'awāṣim*) was very early raised and garrisoned either from amongst local tribes or by foreign mercenaries. Experience of Greek methods of attack and defence taught the Muslims a great deal, but knowledge of the simpler forms of defence was acquired by them even before they came into serious contact with the Greeks. The Prophet himself is said to have learnt the art of entrenchment from a Persian, Salmān al-Fārisī, and employed it in his defence of Medina

[1] Ibn al-Athir, VII, 245.
[2] Cf. *ibid.* (A.H. 92), where the warlike equipment donned by the Muslim envoys to the emperor of China is described.
[3] Tabari, I, 1315. [4] Balādhuri, p. 318. [5] *Ibid.*
[6] *Ibid.* p. 303. [7] Tabari, II, 2014. [8] *Fragmenta Hist. Arab.*, I, 91.
[9] Cf. Ibn al-Athir, X, 44 f. [10] *Ibid.* IV, 163.

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against a threatened attack from the Meccans.[1] In the field, trenches came to be in common use, sometimes for long periods.[2] Thus the Baṣra force which was sent out to combat the Zanj rebels remained entrenched for six months before being driven out.[3]

In the more strongly fortified cities the trench was dug as an additional defence in front of the walls, which were especially thickened and protected with baulks of timber to withstand missiles from siege-engines.[4] Gates and other vulnerable parts of the defences were guarded by mangonels and catapults, which are mentioned as having been used by Musta'īn when Baghdad was besieged by the hostile forces of Mu'tazz.[5] Both for the digging of the defence trenches and for the heavy work of undermining the walls of besieged cities and fortresses, special bodies of labourers were taken with the army, although when they were not available the troops themselves were compelled to undertake tasks of this kind.[6]

For the attack on fortresses and strongly defended points in general, the early Muslim expeditionary forces carried with them engines of war such as mangonels and catapults, the use of which —to judge at least from the name of the mangonel in Arabic—was acquired from the Greeks.[7] As early as A.H. 13 they were in use at the siege of Damascus, seemingly, however, without any great effect, for the city was finally entered by men who swam the moat on inflated skins, flung on to the turrets ropes with running nooses and so climbed the walls and opened the gates.[8]

[1] Ṭabarī, I, 1465. Cf. *ibid.* III, 228.

[2] *Ibid.* III, 355. The art of using concealed pits as defence against cavalry was well known. (Cf. Ibn al-Athīr, VII, 236.)

[3] Ibn al-Athīr (A.H. 256), VII, 163.

[4] Cf. for use of cypress-wood by the Greeks at Kamachon, Balādhurī, p. 184.

[5] Ibn al-Athīr, VII, 94 f.

[6] Ṭabarī, III, 1199; Ibn al-Athīr, A.H. 267.

[7] The Arabic *manjanīq* or *manganīq* would appear to be derived from the Greek *manganikon*, but it is not impossible that the original of the Muslim machine was the *monankon*, a "one-arm" catapult less elaborate than the ordinary torsion catapult, which had two arms moved by twisted ropes or hair. (See further J. Kromayer and G. Veith, *Heerwesen und Kriegsführung der Griechen und Römer* (Berlin, 1928), especially plates 16 ff., and W. W. Tarn, *Hellenistic Military and Naval Developments* (Cambridge, 1930), pp. 12 ff.) I am indebted to Mr Richard Barnett of the British Museum for this reference.

[8] Ṭabarī, I, 2152.

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The Umayyads and Abbasids used siege engines as far afield as India and eastern Persia. At the siege of Daybul, in Sind, Muhammad ibn Qāsim had a mangonel set up which he called *al-'Arūs* ("the Bride") and which was manned by no less than five hundred people.[1] As a rule these engines threw stones[2], but some also threw fire and naphtha,[3] the latter of which was carried as part of the stores of war.[4] At the siege of Heraclea, Hārūn al-Rashīd, who was in command, had sulphur and white naphtha placed with the stones. The whole was wrapped round with tow and set into the holder, where it was set ablaze and shot against the walls, to which it clung, so that they split with the heat.[5] A special body of troops, known as *naffāṭūn* ("naphtha men") was employed to prepare and use the naphtha,[6] and also to deal with it when it was used against the Muslims. On one of Hārūn's campaigns in Asia Minor he found his way barred by the Emperor Nicephorus who had had trees cut down across the road and set on fire. The *naffāṭūn*, who wore special fire-proof garments, plunged in amongst the burning timber and made a way for the army.[7]

At the siege of Amorium the mangonels used were "as wide as four men" and were moved about by being placed on wheeled platforms. These might be used close up against the walls, the intervening moat being filled with sheepskins (taken from the flocks brought for food) stuffed with earth. Where it was not possible to fill in a moat a smaller engine known as an *'arrāda* was brought into use. It could be loaded on to a barge or boat and moved to any suitable place along the wall.[8]

For the shooting of arrows in quantity or for shooting larger and heavier arrows than could be managed by the archers, the Muslim troops under Saladin at the siege of Sihyūn used a machine known as a *ziyār*, which was composed of a number of crossbows, three being the number mentioned in one instance.[9] According to Ibn-al-Athīr a hail of arrows was kept up against the fortress by means of hand-bows, "wheels" (i.e. crossbows),

[1] Balādhurī, p. 437. Cf. *ibid.* p. 390.
[2] *Ibid.* p. 184.
[3] Ibn al-Athīr, VII, 98.
[4] *Fragmenta Hist. Arab.*, I, 24 f.
[5] *Aghānī*, XVII, 82. Cf. Tabarī, III, 79, and the vocabulary of the de Goeje edition s.v. *mushdqa*.
[6] Tabarī, III, 1511. Cf. Ibn al-Athīr, VII, 270.
[7] *Aghānī*, XVII, 45.
[8] Ibn al-Athīr, VII, 98.
[9] Quatremère, *Histoire des Mongoles de la Perse*, p. 286.

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zambūraks (literally "little bees", probably for firing large arro and so called from the humming of the thick bowstring[1]) a these *ziyārs*.[2]

Another engine of war which was designed for direct attack c city walls was the *dubbāba*. It was a movable tower built in sever stages or stories, on each of which were stationed a number o men able to make their onslaught simultaneously at differer levels. Those below were armed with picks and drills while th others used bows and arrows both to protect their own men an to inflict damage on the defenders on the walls. One such *dubbāb* is mentioned as having been in use at the siege of Kamachon i 149/766[3] and Mu'taṣim, at the siege of Amorium had a numbe of them to hold ten men each. The main difficulty in employin them was that as they were extremely cumbersome they were liable to become immovably imbedded amongst the sheepskins stuffed with earth which were used for filling in moats and across which they had to be dragged. Particularly if the defenders kept up a fire of arrows and stones, as the Greeks did at Amorium, the men in any *dubbāba* which was thus brought to a standstill in the ditch, could be rescued only with great difficulty.[4]

At the siege of Kerak in 580/1184, after Saladin had captured the outer works he found a deep trench separating him from the citadel. His attempts to fill it being for a long time hampered by a heavy fire of arrows and flaming naphtha from the defenders, he was compelled to find some method of protecting his men at work and ordered the erection of a penthouse of beams and bricks under cover of which his men were enabled to proceed with their task.[5]

When there was no moat or when it was possible to attack a defensive wall directly, tunnelling was resorted to and a specially trained body of men known as *naqqābūn* ("piercers") who used picks and drills[6] was brought into action. They were protected while at work by a barrage of arrows from the bowmen in their

[1] In modern times the same name was given in Persia to a small cannon.
[2] Ibn al-Athīr, XII, 5 f.
[3] Balādhurī, *Futūḥ*, p. 184.
[4] Ṭabarī, III, 1248. Cf. Quatremère, *ibid.* p. 284 b, and Dozy, s.v. *dubbāba*. See also M. Amari, *Biblioteca Arabo-Sicula*, second Appendix (Leipzig, 1887), p. 22.
[5] Ibn al-Athīr, XI, 333 f. [6] Cf. *ibid.* X, 25.

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rear.[1] Sometimes also a *kabsh*, or ram, was employed. Where the wall was too strong to be pierced, scaling ladders were brought into use.[2]

Another way of storming a strong point was by keeping up an unremitting onslaught and giving the defenders no rest. This was Saladin's method at the siege of Barzīya (584/1188), when he divided his force into three sections, each of which attacked in turn and without any interval until the Frankish defenders were compelled to surrender. The method was especially effective in this case because the Franks sallied out at the first attack and were greeted by a destructive hail of arrows from the men kept unexpectedly in reserve.[3]

A properly equipped force carried all the requisite engines of war with it. In the war against the Zanj rebels, who inhabited the marsh lands of southern Iraq, the army of Muwaffaq brought not only mangonels and catapults with it, but must also have carried much of the ammunition, for stones are unobtainable locally in that region of Iraq.[4] They also carried naphtha and requisite tools such as axes,[5] and further took with them the necessary craft for transporting men across rivers and up the narrow channels which are the only approaches to the numerous villages of the marsh. Long canoes of shallow draft, made of local reeds pitched over with bitumen, probably formed the major part of these craft, but there were also larger boats equipped with rudders and yet with sufficiently low freeboard to be concealed among the reeds.[6] For the handling and navigation of these vessels, boatmen were employed, as distinct from the ordinary fighting force.[7] In the chief attack on the city of the Zanj leader, al-Khabīth, there were as many as ten thousand of these watermen drawing pay, in addition to the crews of the transports which carried men and supplies.[8]

When they are desirous of emphasizing the importance of any particular campaign, the Muslim historians stress the fact of the army's being particularly well provisioned. Thus we are told that for the Zanj campaign, Muwaffaq, who was in command, had

[1] Ibn al-Athīr (A.H. 268), VII, 254; XI, 285, etc.
[2] *Ibid.* (A.H. 462), X, 25, and (A.H. 567).
[3] *Ibid.* (A.H. 584), XII, 8.
[4] *Ibid.* VII, 244.
[5] *Ibid.* VII, 270.
[6] *Ibid.* (A.H. 266, 267), VII, 234 ff, 274.
[7] *Ibid.* VII, 244 (?).
[8] *Ibid.* VII, 274.

arranged with the Baṣra merchants to supply him with stores in large quantities which were kept in a depot (the town of Muwaffaqīya) specially built for the purposes of this long war against the Zanj, who had proved themselves a determined foe.[1] Another occasion on which the army was well supplied was for the invasion of Asia Minor by Mu'taṣim in 244/838. The army is said by Michael Syrus to have had with it thirty thousand "merchants and providers" as well as thousands of camels and mules.[2]

Ibn al-Athīr reports further how in the reign of Mutawakkil a Sudanese tribe kept up a series of attacks on the workers of a Muslim-owned mine which was situated in their territory and paid a royalty of about one-fifth of the proceeds to the Egyptian treasury. As the attacks persisted, work and the consequent payments ceased, and complaint being made to the Caliph, he took counsel on the matter and was told that access to the territory of the culprits was difficult since it lay across desert country, and that any force which was sent against them would have to be sufficiently well supplied to make the journey outwards and back again on its own resources. The Caliph's 'āmil in charge of military operations in Egypt was thereupon told to bring up his force to full strength and to dispatch it equipped with all that would be required. The commander of the expedition marched towards a point on the Red Sea where seven ships laden with meal, olives, dates, barley and fine flour had been ordered to be in waiting for him and supply him with necessaries as they were required. In the meantime the chief of the Sudanese tribe, not knowing of the ships, evaded direct attack and planned to wipe out the Muslims, as he had destroyed other forces, when their food and drink were exhausted. But on this occasion his plan miscarried, for he was forced to give battle to an enemy well supplied and capable of defeating him.[3]

The historians do not in general concern themselves with mentioning the important question of supplies, and these reported instances would appear to be exceptional. The fact is that as a rule the Muslim forces lived, or hoped to live, on the country they invaded, sometimes with disastrous consequences for themselves,

[1] Ibn al-Athir, VII, 246.
[2] J. B. Bury, *Eastern Roman Empire*, p. 263 n. 3.
[3] Ibn al-Athir, VII, 50 ff.

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as in the unsuccessful attempts, made during the Umayyad period (in 673 and 718) to take Constantinople, and in the early Abbasid period (under Hārūn al-Rashīd in 806 and under Mu'taṣim in 838) to gain a permanent footing beyond the Taurus.

It remains now to deal with the army on the march and in camp. The early campaigns, it must be remembered, were not mere raiding forays but were in part "colonizing" expeditions so that the warriors were accompanied by their families when they set out for Persia, Syria and Egypt. In Umayyad times and earlier[1] the commanders had taken their wives with them on ordinary plundering raids and even where serious fighting was in contemplation,[2] but for the more distant expeditions the transport of the men's families was encouraged as part of a definite policy of colonization. For this reason the drafts sent by Ḥajjāj from Baṣra and Kūfa went with their women and children to Khurāsān[3] and similarly when Qutayba marched on Kāshghar, those of the troops who had families were accompanied by them so that they could be settled at Samarqand and other places on the way. Once the army had crossed the Oxus, guards were stationed at the fords to prevent anyone returning without leave.[4]

Generally the women and children were carried in litters[5] accompanying the *sāqa* or rear-guard following in the wake of the main force. The value of their presence is variously estimated both as an encouragement to the men in battle and as a drawback, but the former appears to be more generally to have been true, for on occasion the women could give a good account of themselves, as they did at the battles of the Yarmūk and elsewhere,[6] and also at the siege of Bukhārā in 90/709, when a body sallying out from the beleagured city broke right through the rear of the besiegers.[7] When a forced march was necessary, either to take the enemy by surprise or for some other reason, the impedimenta and presumably with them the women and children, were left behind under guard. This happened in the first raid on Samarqand when Qutayba advanced with the cavalry and archers only.[8]

On the march the "five" formation was kept, with the advanced

[1] Cf. Wensinck, *The Muslim Creed* (Cambridge, 1932), p. 42.
[2] Cf. Ṭabarī, I, 2888 f. and *Aghānī*, XVI, 33.
[3] Ibn al-Athīr (A.H. 80 and 83).
[4] *Ibid.* (A.H. 96), V, 2.
[5] Cf. Balādhurī, p. 167.
[6] Ṭabarī, I, 2100 and 2347.
[7] *Ibid.* II, 1201.
[8] Ibn al-Athīr (A.H. 93).

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guard going ahead and with the centre and right and left wings forming the main body. The *sāqa*, as indicated, brought up the rear and usually contained the baggage, siege engines, heavy equipment and supplies.[1] Normally also, as has been shown, the women and children accompanied it, as well as the slow-moving flocks and herds intended for supplies. But this was the case apparently only in earlier times, for in the Crusading era it appears to have been the practice to send the animals and impedimenta ahead under a light guard, which on occasion proved insufficient to prevent their capture by the enemy.[2]

The column marched to the beating of drums. When that ceased the column halted wherever it happened to be.[3]

Camp sites in war were carefully chosen by an official especially appointed for the purpose.[4] As a rule, when a halt of any length was proposed, camps were surrounded by a trench for defensive purposes,[5] and as additional protection in enemy territory the warriors stood to arms in their proper formation.[6] When for any reason the digging of a trench was omitted, still further precautions were taken to ensure safety. On the march against Bābak, the rebellious Khurramī heretic, Afshīn, the commander of the Caliph's army, by his orders placed the main body in the midst of a ring of calthrops[7] when he encamped, while a mounted patrol kept circling, night and day, about the camp at a distance of a league.[8] Within the camp shelter was provided, at any rate for senior officers, by large tents in which they ate their meals and slept, interviewed prisoners and performed other duties.[9]

In peacetime troops of a garrison were billeted on the townspeople where possible. Frequently, the exactions and misbehaviour of the soldiery led to local unrest, and where that occurred separate camps had to be set up. This was the case when Ḥajjāj ibn Yūsuf billeted his Syrian troops on the Kūfans, whose protest led to the evacuation of the army and the building of the garrison city of Wāsiṭ;[10] and also much later, when the Seliūqs at Baghdad

[1] Ṭabarī, III, 1238, *Fragmenta Hist. Arab.*, II, 485 f.
[2] Cf. Ibn al-Athīr (A.H. 517), X, 428 f.
[3] Ṭabarī, III, 1203.
[4] Cf. Ibn al-Athīr, IV, 162 f.
[5] See above, p. 438.
[6] Ṭabarī, III, 355, 1202.
[7] The text (Ṭabarī, III, 1197) has *fi-'l-ḥasak*.
[8] *Loc. cit.* Cf. *ibid.* III, 1200.
[9] *Ibid.* III, 1350.
[10] Ibn al-Athīr (A.H. 83).

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quartered themselves on the citizens, to their great disturbance,[1] although in other places the army had camps of their own.[2] In the frontier city of Malaṭya (Melitene) the Caliph Manṣūr quartered four thousand men, who were divided into *'irāfas* ("squads") of from ten to fifteen men each. For each *'irāfa* there was built a two-storied house with a stable, and provision was made locally for their keep.[3]

We have dealt so far in the main with the army of the Eastern Caliphate at Baghdad. Something must also be said concerning the Muslim armies which existed outside it and, in particular, concerning the important military organizations of the Fāṭimids, Ayyūbids (especially under Saladin), Mamlūks and Turks, all of which had characteristics in common.

The Fāṭimid forces took their rise in North Africa when 'Abd-allāh, the chief propagandist of the 'Alid claims, gathered an army of forty thousand men, "leaving no brave man in Ifrīqiya whom he did not attach to his armies".[4]

The numbers increased rapidly during the dynasty's period of power in Egypt and Syria. According to the Persian traveller Nāṣir-i Khusraw, who visited Egypt in 1047, there was a large and well disciplined army in Cairo at the time. In his *Safar-nāma* he describes the army as it stood in parade order on the occasion of the ceremony of the opening of the Nile sluices.[5] The whole army was present, he says, mounted or afoot, regiment after regiment, each with a name and title. The cavalry regiments comprised twenty thousand men from Qayrawān in North Africa, fifteen thousand Bāṭilīs from north-west Africa and thirty thousand mixed mercenaries, negroes and others. Of infantry there were twenty thousand black Maṣmūdīs, also from North Africa, men of good stature but of hideous appearance, who fought with sword and spear and could use no other weapon;[6] there were also ten thousand men known as "orientals", men born in Egypt but of Persian or Turkish origin. There was further a regiment known as the "Bought Slaves", who, as their title shows, were acquired in the market-place. They are set down as being thirty thousand

[1] Ibn al-Athīr, (A.H. 446), IX, 430 f.
[2] *Ibid.* IX, 432.
[3] Balādhurī, pp. 187 f.
[4] Ibn al-Athīr (A.H. 296), VIII, 30.
[5] Ed. and tr. Charles Schefer (Paris, 1881), pp. 45 f.
[6] *Ibid.* p. 42.

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strong. A large body was that of the Bedouins, fifty thousand men of the Ḥijāz who fought with the spear. Moreover there was, under separate command, a large palace guard of infantry, said to number ten thousand men, drawn from numerous different countries and arranged in detachments by nationalities, each man fighting with the weapons to which he was accustomed in his own land. Lastly, there were thirty thousand *Zanj*, or Ethiopians, men who fought with the sword. The numbers given total two hundred and fifteen thousand, a figure which was at times increased or diminished. Yet even towards the end of the sovereignty of the Fāṭimids their army still numbered forty thousand horsemen and thirty thousand foot, nearly all negro slaves.[1]

The scheme of military organization adopted by the Fāṭimids was an elaborate one, although it may be doubted whether in practice it was as efficient as the ideal intended. The Caliph settled matters of policy with the help of his viziers and paid his troops, through the agency of the *Dīwān al-Jaysh*,[2] with money derived from the taxation of lands rented out to various classes of the community and from the crops raised, one-third of the total sum accruing being devoted to military purposes. The pernicious system of granting fiefs to the soldiery was not yet in force.[3]

The vizier had charge of the dīwān and military affairs generally unless he was a "Man of the Pen", and under him and in immediate command of the army was the *isfāh-sālār*. The ranks below him were the amīrs in order, namely, the gold-chain amīrs, the sword-bearers and the regimental officers. Of the regiments there was a great number, each called after a Caliph or vizier, but sometimes also after the nationality of the men composing it: e.g. Ḥāfiẓīya (after a vizier named Ḥāfiẓ), Rūmīya (Greeks), Saqāliba (Slavs) etc.

The Fāṭimid régime was finally displaced by that of Saladin and the Ayyūbids. His army, even at its best, did not, in spite of the admiring comments of the historians, surpass that of his predecessors in numbers, though in efficiency it was far higher. It is recorded under the events of the year 567/1171 (Muḥarram), that after a proclamation from him ordering a general mobilization of

[1] Maqrīzī, *Khiṭaṭ*, 1, 86, 94. [2] See above, p. 422.
[3] See Maqrīzī (*Khiṭaṭ*, 1, 86), who quotes Ibn Mammātī.

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the forces owing him allegiance, multitudes came "such that no king of Islam had ever mustered the like of them". Actually 147 *ṭulbs* came, the *ṭulb* in the Ghuzz (Turkish) language representing a chieftain entitled to a banner and a trumpet salute, together with his own company of mounted men, numbering between seventy and two hundred. This was not the total number of *ṭulbs* available, for twenty were absent, and the *ṭulbs* present were not at full strength, seeing that the estimated number of troopers mustered at the date mentioned was only fourteen thousand.[1] Most of these were paid free-men, known as *ṭawāshīya*, the *ṭawāshī* being a knight in receipt of an allowance, normally of between seven hundred and one thousand *dīnārs*, although it might be as low as one hundred and twenty, out of which sum he had to provide ten baggage-animals for common use and also a slave to carry his own arms and equipment.[2] The whole force was supplemented by a number of black slaves and presumably by volunteers.

At his accession to power, Saladin had abolished the army of negro slaves, officered by Egyptians, Arabs and Armenians, which the Fāṭimids had maintained in Egypt, and had substituted a special force of Kurds and Turks, who numbered no more than twelve thousand horsemen.[3] The reason for this step appears to have been one of finance. In the year 577/1181 Saladin was forced to investigate the question of military fiefs and determined upon a strength of about nine thousand troopers, one hundred and eleven amīrs, about seven thousand *ṭawāshīya* and fifteen hundred or so negro slaves (*qarāghulāmīya*).[4] Six years later, at the siege of Tiberias, his army numbered twelve thousand knights in receipt of allowances.[5] But he had further a number of volunteers, and in case of need he could always summon supporters to do voluntary service. Against the Crusaders he had the help of fellow-Muslims in Mosul and Mesopotamia generally, as well as in Egypt and Syria.[6] Even he, however, could not entirely control their movements. When, after the fall of Jerusalem, the Muslim force was held in check before Tyre, a portion of the volunteer army, represented by the richer and more powerful chiefs, were for

[1] Maqrizi, *Khiṭaṭ*, I, 86.
[2] Cf. Quatremère, *Mamlouks*, I, i, 253.
[3] Maqrizi, *Khiṭaṭ*, I, 94.
[4] *Ibid.* I, 86.
[5] Ibn al-Athir (A.H. 583), XI, 350 f.
[6] *Ibid.* XI, 349 ff.

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departing home. The ostensible reason was that the siege was likely to prove abortive, but actually many of them, knowing that Saladin's field coffers were empty, were afraid that he might force loans from them in order to carry on the campaign. In the end the general was compelled to abandon the siege and permit his troops to return to their homes for the winter on condition that they returned in the spring. The men "from the East and Mosul", as also those of Syria and Egypt, therefore departed, leaving him at Acre with no more than his personal following.[1]

Something has already been said of Saladin's battle and siege tactics. For his order of battle he retained the "five" formation, but he varied it by employing a picked force of archers for the vanguard (the *jālishīya*)[2] instead of keeping all the best troops for the centre. It was upon these archers that the commander relied for his opening assaults, the wings and centre playing their part at the appropriate situation in the battle. The *sāqa* as usual was present in the rear.

With the death of Saladin his army dispersed, although his son al-Malik al-'Azīz could still command the services of over eight thousand knights, each of whom had a more or less considerable following, making a total which Maqrīzī, doubtless with some exaggeration, puts at two hundred thousand.[3]

When power passed from the Abbasids to their Turkish mamlūks ("slaves") who turned themselves into sulṭāns, there came into being a national military system which has perhaps been equalled only in Europe in modern times. It was unique in Islam, although their kinsmen, the Ottoman Turks, created one that approached it when they founded their corps of Janissaries. Like Saladin, the Mamlūks limited their recruiting to Turks and a comparatively small number of Kurds. It is said that the number of Turkish slaves in Manṣūr Qalā'ūn's retinue was between seven and twelve thousand, a number which afterwards increased until the army in the days of al-Nāṣir Muḥammad ibn Qalā'ūn comprised twenty-four thousand knights.[4]

When the Qalā'ūnids fell from power in 784/1382, the new sulṭān, al-Malik al-Ẓāhir Barqūq, disbanded the so-called

[1] Ibn al-Athīr, (A.H. 583), XI, 368.
[2] *Ibid.* XI, 350 f. For the *jālishīya* cf. Quatremère, *Mamlouks*, I, pp. 225, n. 1; 226 f.
[3] Maqrizi, *Khiṭaṭ*, I, 94.
[4] *Ibid.* I, 94.

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Ashrafī (Turkish and Kurd) army of his predecessors and formed a new bodyguard for himself consisting of Circassian slaves either bought or enlisted, and numbering in all about four thousand men. These, too, were the nucleus of a force which rapidly increased its numbers.

The system followed was similar under both parts of the Mamlūk régime. The army was divided into three classes; the first enlisted soldiers (*mustakhdimūn*), the second *mamlūks* or slaves proper, both of which classes received fixed pay and allowances from the sulṭān, and a third class to which the other two might not belong. This was the company of the feudatories, the so-called "company-soldiers"[1] who received lands in return for their services.[2] Each member of this privileged class received a separate fief, of which the annual value might be as high as thirty thousand *dirhams* and as low as ten thousand, and was granted in addition an allowance for maintenance which might amount to five thousand *dirhams* where the calls on any particular fief were heavy. Thus the leader of a company might go out to battle at the head of ten men who ate at his table, while their slaves, who formed the rank and file of the troopers, were also supplied from his kitchen. The numbers varied, but it was for their maintenance that the chief part of his allowance was expended.

At the time (A.D. 1296), when the Mamlūk Sulṭān Manṣūr Lājīn succeeded to the throne, the territory of Egypt was divided into twenty-four parts, of which four formed the private estate of the sulṭān, ten belonged to the "company-soldiers" and ten to the amīrs or officers in high command. The latter, however, had seized the best lands, with the result that the subordinate soldiers were reduced to poverty and brigandage. Lājīn brought about a reform which consisted in redistributing the available lands so that eleven out of the twenty-four parts went to the amīrs and other officers of high rank, and nine to the rest of the army. But this led to unrest amongst the amīrs, and in spite of changes in subsequent reigns the system was never established to the satisfaction of all those whose living depended on it.[3]

The troops as a whole were divided into four grades, of which

[1] *Ajnād al-ḥalqa* (lit. "soldiers of the ring").
[2] See Quatremère, *Mamlouks*, I, i, 161, and Maqrīzī, *ibid.*
[3] Maqrīzī, *Khiṭaṭ*, I, 94.

the chiefs were known as "chiefs of thousands".[1] They had command of at least one hundred troopers or were in charge of detachments of craftsmen. Their number after the time of al-Nāṣir Muḥammad ibn Qalā'ūn was restricted to twenty-four for the whole of Egypt. Next to them came the "drum-commanders",[2] unlimited in number and each in command of forty troopers. In this group were reckoned the lesser departmental heads, revenue officers and other officials. They were followed by the "commanders of tens"[3] and the "commanders of five" who were no more than upper-grade troopers.[4]

Maqrīzī describes the training of the young *mamlūk* recruit. As soon as he was brought as a child by the slave-dealer he was placed before the sulṭān for his approval and then consigned to his proper class. The first part of his course was undergone in the school, where he was taught his letters and the reading of the Koran, as well as being instructed in the duties of religion and the ritual of prayer. On reaching puberty the more strictly military part of his training began. This consisted of horsemanship, archery, manipulation of the lance and throwing of the javelin. Those who showed ability were advanced grade by grade until they became military amīrs. Others whose talents lay in other directions might become legists, poets or accountants, but all were submitted to the strictest military discipline and might be called upon for military duties.[5]

Closely modelled upon the system devised by the Mamlūks was that of the Janissaries (*Yenī Cherī*) "the New Corps" of the Ottoman army whose foundation is ascribed to Sulṭān Murād I in 763/1361.[6] They formed at first only a small force selected from amongst the '*ajam oghlu* ("sons of foreigners"), who were levied from the sulṭān's Christian subjects in Thrace. The training of those taken for Janissaries resembled in essentials that of the *mamlūks* and was carefully supervised.[7] Those who showed no particular military ability were left to become army tradesmen.

[1] Tukish *bīn-bāshī*.
[2] *Umarā al-ṭabal-khāna*.
[3] Turkish *ōn-bāshī*.
[4] Qalqashandī, *Ṣubḥ al-a'shā*, IV, 14 ff.
[5] Maqrizī, *Khiṭaṭ*, II, 213.
[6] Thus von Hammer (*Staatsverfassung*, II, 192), who does not give the authority for his statement. D'Ohsson, *Tableau général* (VII, 308), says the corps was founded by Orkhān in 1330.
[7] F. Babinger, *Hans Dernschwam's Tagebuch einer Reise nach Konstantinopel* (Munich, 1923), p. 60.

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The better men were promoted by slow and regular stages, and picked ones could reach high rank, for it was from amongst them and their kind that the reigning sovereign took his chief ministers. The rank and file were infantry. They were divided into regiments and companies which varied in size and numbers according to the totals of men recruited. Under the old recruiting law (the *devshirme*) of Murād I (by which Christian boys alone were taken for the corps of Janissaries although the rest of the army was reserved for Muslims), the numbers remained comparatively small, so that under Sulaymān I (Qānūnī) there were not more than twelve thousand Janissaries. Under Murād III the numbers had reached forty-five thousand men, who, however, being never regularly paid, had become a hotbed of intrigues and agitations and were closely linked with the Bektashī dervishes.[1] They were finally disbanded, many being treacherously slaughtered by Sulṭān Maḥmūd II in 1241/1826.[2]

In addition to the military arm, a navy has at one time or another in the history of Islam played an important part in the machinery of attack and defence employed by the Caliphate or its successors. The desert Arabs who made up the earliest Muslim forces, being unfamiliar with the sea, feared and detested it, and pious legend makes Omar refuse to entrust any Muslim lives to its terrors when he was urged by Mu'āwiya to attack the Byzantines from the sea.[3] That competent warrior was later able to persuade the Caliph 'Uthmān to permit a sea-raid, although even he stipulated that no man was to be compelled to go to sea against his will, but that all who took part should be volunteers.[4] Mu'āwiya is said to have been the first to attack the enemy by sea and to have made fifty summer and winter raids, the objectives of which are not

[1] See Barbier de Meynard, *Considérations sur l'Histoire ottomane* (Paris, 1886), p. 61.

[2] Cf. Khidr Ilyās Efendī, *Ta'rikh-i Andarūn* (A history of the imperial household during the reign of Maḥmūd II) (Stambūl, A.H. 1276), pp. 367–71. For further details concerning the Janissaries, see the works just quoted and Eugenio Alberi, *Relazioni degli Ambasciatori Veneti al Senato*, 15 vols. (Florence, 1839–63), especially III, 3, 263 ff.; A. H. Lybyer, *The Government of the Ottoman Empire in the Time of Suleiman the Magnificent* (Cambridge, Mass., 1913); H. A. Gibbons, *The Foundation of the Ottoman Empire* (Oxford, 1916); J. K. Birge, *The Bektashi Order of Dervishes* (London, 1937).

[3] Cf. Tabarī, I, 2820 ff.

[4] *Ibid.* I, 2824. (Cf. Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, II, 33.)

specified,[1] though Cyprus is mentioned as having been one of the earliest of them. That raid was made from the Syrian coast in 28/643, in which year also an attack was launched against the island from Egypt.[2] Then, as later, the ships' crews, including rowers, helmsmen etc., were distinct from the actual warriors,[3] being Greeks or Copts, while the latter were Muslims, either true Arabs or *mawālī*. From the Greek and Arabic papyri of about 710–11 (discovered in Egypt and dealing with that country as an Umayyad province), it is clear that the annual raids against the Bzyantines were carried out by sea as well as land, the naval raids being designated by the names of the places from which the fleets set out, e.g. Egypt, Anatolia, Africa or "from the sea". The crews were raised by conscription in the same way as the armies were in the various territories subjugated by the Muslims, being drawn from the classes of the community which supplied the ordinary crafts and trades; and they, like the impressed soldiers, received pay and an allowance of food.[4]

In 34/654–5[5] a large fleet, said to have numbered over two hundred ships, was sent by Mu'āwiya to attack the Byzantines, who had over five hundred ships, and gained a decisive victory.[6] An eye-witness's report of the encounter is that the wind at first was against the Muslims, who anchored for a time not far from the shore, with the enemy fleet close by. The wind then dropped and the Muslims appear to have given the Byzantines the alternative of fighting out the battle either on land or sea. Eventually the fleets engaged on the sea, ship grappling with ship and the men fighting at close quarters with daggers.[7] The sailors, who were Copts,[8] as distinct from the Muslim warriors, appear to have taken no part in the actual struggle.

In A.D. 717, on the occasion of the combined attack by the Umayyad land and sea forces on Constantinople, the Muslim

[1] Tabarī I, 2824. (Cf. Ibn Khaldūn: *Prolégomènes*, ed. Quatremère II, 33).
[2] Tabarī, I, 2826. [3] Cf. Ibn al-Athīr, VII, 244, 274.
[4] Cf. *Greek Papyri in the British Museum*, IV (*Aphrodito Papyri*, ed. H. I. Bell), xxxii ff.
[5] Some historians place the event in A.H. 31. Cf. Tabarī, I, 2865.
[6] From the large number of vessels engaged the battle was called "the Raid of the Masts". It may be that the Muslim historians confuse this battle with one in which the Byzantine fleet was wrecked by a great storm. See L. Caetani, *Annali dell 'Islam*, VIII (Milan, 1918), 92 ff.
[7] Tabarī, I, 2868; Maqrizī, *Khiṭaṭ*, I, 169. [8] Tabarī, I, 2870.

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navy, which, according to the Greek historians numbered eighteen hundred vessels, was utterly routed by the Byzantines. The Muslim annalists do not report the full extent of the disaster which overtook this expedition, and the details have to be culled from the records of their enemies.[1]

Although there were some vessels in the service of the Caliphs of Baghdad,[2] the raids upon the various Mediterranean cities and the capture of the larger islands were in general directed from North Africa and Spain. But Egypt also maintained a fleet under the Fāṭimids, and warships were built at Cairo, Alexandria and Damietta.[3] The Byzantine emperor Leo speaks[4] of the large and heavy *cumbaria*, slow-moving because of their weight, which the Saracens used to good effect at close quarters. At one time there were five thousand sea-captains employed under command of ten admirals, of whom one was in supreme command. These higher commanders had fiefs allotted to them in like fashion with the generals of the army.

With the decline in the fortunes of the Fāṭimid dynasty their navy fell into decay, although there were still some vessels of war left at the very end.[5]

The Egyptian fleet was revived under Saladin, who created a special dīwān for it and allotted special sources of revenue for its maintenance. In 569/1173, on the occasion of the Sicilian attack on Alexandria, the harbour is said to have been crowded with war-craft and merchant vessels.[6] On Saladin's death decline once more set in; interest in the fleet disappeared, and men had to be pressed into its service. They were seized in the streets, those who could not free themselves by bribery or other means being chained to their posts during the day and kept in prison at night. As a result of the degeneracy and corruption that prevailed in consequence of this method of recruiting, the word *uṣṭūlī* ("naval man") became a term of abuse.[7]

It was in Spain that the greatest interest was taken in naval matters. Muhammad I in 266/879–90 had ships built on "the

[1] Ṭabarī, II, 1314 ff. and cf. J. B. Bury, *A History of the Later Roman Empire* (London, 1889), II, 401–3.

[2] Cf. Ibn al-Athīr, VII, 98.

[3] See Maqrīzī, *Khiṭaṭ*, II, 193 f.

[4] *Tactica*, XIX, 67.

[5] Maqrīzī, *ibid.* I, 94 *ad fin.*

[6] Amari, *Biblioteca Arabo-Sicula*, second Appendix (Leipzig, 1887), p. 21.

[7] Maqrīzī, *Khiṭaṭ*, II, 194.

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river of Cordova" (i.e. the Guadalquivir) for use in the Atlantic against the refractory province of Galicia, which was more vulnerable from that side. But his sailors were unaccustomed to the open sea, and in this expedition the ships separated as soon as they emerged into the Atlantic, and only a few ever returned.[1] Within the Mediterranean, however, the Moorish fleets assisted for centuries in preserving most of the islands and much of the coast-lands as Muslim territory and provided the nautical vocabularies of Europe with numerous Arabic words.

When the Moors had been driven out of Spain, the Turks and the Barbary corsairs remained to carry on the Muslim nautical tradition in the Mediterranean.[2] They dominated the inland sea for over three centuries, until well into the nineteenth century, being only subjugated when the French empire in North Africa came into being.[3]

To the record provided of the practical details of the Muslim system of attack and defence must be added, for its comprehension as a whole, some account of the Muslim theory of war and military organization. In large measure it was derived, like much of the practical side, from the experience gained against the Persians and Byzantines, but it was elaborated in ways peculiar to the Muhammadan mind, under the joint influence of the precepts of Islam and the reported sayings and doings of the Prophet. The great Muslim philosopher, Ibn Khaldūn, states the facts clearly in his treatment of the subject of war and military organization.[4] His view of the art of war, namely, that it means the way to fight battles successfully, is in essence correct, although lacking in all particularity. Under the Caliphate, he says, there were two methods of doing battle; the first being the Persian way of attacking in line, and the second, that of the Bedouin Arabs and of the Berbers, which consisted of raids by unorganized groups, their speedy retreat and sudden return. He claims that the method of advancing in line and organized formation is more certain of victory and

[1] Ibn al-Athīr, VII, 232.

[2] See Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, II, 34 ff, where some facts are to be gained, although the confused generalities of the chapter are not characteristic of the author's usual precision.

[3] See further, S. Lane-Poole, *The Barbary Corsairs* (London, 1890).

[4] *Prolégomènes*, ed. Quatremère, II, 65 ff.

more formidable than the other, for the reason that the lines of the attackers are well ordered and regular, in the same way that arrows are arranged or the ranks of the Muslims in prayer. Being thus properly marshalled the troops stand more steadily in the battle and are to the enemy as impregnable as a continuous wall or a strongly constructed fort. And this opinion is confirmed by the verse of the Koran (64) already quoted above.

Although the pagan Arabs knew only the raiding (*karr u farr*) method of attack, they soon learnt to attack in line; and for two reasons. One was that since their enemies fought in line formation they were compelled to do likewise, and the second was that they were desperate fighters in their *jihād* (struggle against infidels) and the line formation is more suited to men engaged in a struggle to the death.[1]

The books of *fiqh* are not without their chapters on war, although they naturally deal with its legal aspects. But from the list of the duties for which the commander of an army is responsible some idea may be gained of the Muslim view of the military art. According to Māwardī, the law demands that the commander of a force shall be responsible for its security. He must guard his men against surprise, investigating all places in which an ambush is possible, and he must so protect his main body with outposts and guards on all sides that they shall have security for their persons and their belongings when they are not fighting. If any property is left behind in a campaign, that too must be made secure. The commander is responsible for choosing the site on which the enemy shall be offered battle. It should be a place as level and as well supplied as possible with water and pasture. Also it should be guarded by such natural features (as mountains or streams) on the flanks and outskirts that the site is of use in the actual battle and a source of security. He must ensure adequate supplies of food for his men and of fodder for the animals. Moreover, he must inform himself of the movements and strength of the enemy so as to be secure against their tactics and have sufficient power for his attacks on them. He must dispose his troops both for the battle-line and for the reserves and have sufficient to guard his flanks. In the battle he must urge his men to victory, by making light of the enemy for them, by promising

[1] *Prolégomènes*, ed. Quatremère, II, p. 70.

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those who are steadfast the rewards of Allah if they should reach the next world, and, if they remain alive in this world, tribute and an extra share of booty. He must apply his forces for such purposes only as Allah has ordained and such as come within the laws of Allah. He may not permit any of his troops to engage in trade or agriculture, either of which may seduce them from their real duty of combating the infidel.[1]

In the actual battle the commander-in-chief may not himself go out in single combat against a champion from the enemy side.[2] As to those whom it is lawful to slay, the *fiqh* declares that a Muslim in war may slay any unbeliever (idolator) whether combatant or not, although there is dispute whether old men and monks may be slain. Yet women and children are not to be slain, nor slaves and other menials. No man, moreover, may hamstring or otherwise destroy a horse, for it may be a source of strength in furthering God's purposes and of use in the struggle against His enemies.[3]

Somewhat more in accord with practical experience are the principles of war laid down by the Moorish essayist, Abu Bakr of Tortosa, already quoted. According to him war means deception,[4] and only in the last resort is it necessary to set troops to fight at close quarters or to launch army against army. To gain the victory the commander must use strategy, and when he has used it to the best advantage he must clinch matters with his troops.

As for the order of battle, it is a principle well known, he says, amongst men experienced in wars, that the boldest fighters and stoutest warriors should be stationed in the centre. Then, even if the wings are driven back, all eyes will look to the centre, and if its banners are flying and its drums beating it will become a rallying-point for the wings, so that every fugitive will take refuge therein. But if the centre is broken, the wings will be destroyed. Many a time has victory been achieved by the centre after the wings have been routed, but seldom has the contrary occurred.

The most effective stratagem in war is the ambush. Not too many men must be employed in it; one good one being better than ten thousand others. A multitude destroys the possibility of

[1] Māwardī, *Constitutiones Politicae*, ed. Enger, pp. 71 f.
[2] *Ibid.* p. 67. [3] *Ibid.* p. 70.
[4] It was a view not uncommonly held. Muhallab, the Umayyad governor in Persia, in his death-bed counsels told his sons that foresight and cunning were of more avail in war than bravery (Tabarī, II, 1083).

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surprise, and in surprise lies destructive effect. The best number for a guerilla expedition is four hundred, and the best army is four thousand strong.

The best battle-formation which the author says he ever saw in his own country, was where the infantry with various rallying-points formed the first line, with good shields, long lances and sharply pointed javelins. Each man knelt on his left knee with his shield upright before him, while his lance was fixed by the butt in the ground behind him and inclined forwards towards the enemy. Behind the infantry were the picked archers, "whose arrows pierced all shields", and behind them again were stationed the cavalry. When the Christians (*Rūm*) advanced, no Muslim stirred until they came within range, and then the archers transfixed them with their arrows and the infantry with their javelins, while at closer quarters still the spear-points met them. As the enemy broke the cavalry came forward "and obtained from them what God willed".[1]

Abu Bakr's treatise on the art of war is but one chapter of his "Lamp for Kings". Other works exist which are devoted entirely to the subject. One such work, which is based upon Aelian's *Tactics* (although containing other things dictated by Muslim precept and experience) is a practical manual[2] by 'Īsā ibn Ismā'īl al-Āqsarā'ī, who wrote in the seventh century of Islam, giving instruction in archery, the use of the spear, sword, and other weapons, the disposition of troops on the march, in camp and on the battlefield. Chapters are devoted to the question of military intelligence and the agents to be used for obtaining reliable information, to guards and outposts, days propitious for beginning a march (the Prophet favoured Thursday, which is therefore a day to be chosen), the proper equipment for the various branches of the army, and to other subjects of military interest.[3]

[1] Abu Bakr al-Turṭūshī, *Sirāj al-mulūk*, ch. 61, 298 ff.

[2] It is entitled *Kitāb fī Faḍl al-jihād wa ta'līm al-furūsiya* (A book on the Excellence of the Holy War and on Instruction in Horsemanship), *Nihāyat al-sūl wa'l-umnīya fī ta'lim al-furūsīya* ("The Aim of Ambition and Desire in Instruction in Horsemanship"). Brockelmann, *Geschichte d. Arab. Litteratur* (I, 496), mentions two separate works with these titles by Najm al-Dīn Ḥasan al-Rammāḥ al Aḥdab, who died in 694/1294.

[3] Cambridge University Library MS. Qq. 277. See Ḥājjī Khalifa, VI, 126. Wuestenfeld's *Das Heerwesen der Muhammedaner* (Göttingen, 1880) is based on this work.

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CHAPTER X

ISLAMIC COSMOLOGY AND OTHER SCIENCES

The sciences to which men in cities devote themselves, either in study or teaching, fall into two divisions. The one comprises those "natural" in man, who is guided thereto by his reason, while the other contains those which are "traditional", being acquired by transmitted report from those who instituted them. In the first division are included the philosophic sciences, which are those which a man may acquire by his inborn power of cogitation, while in the second are the transmitted institutional sciences, all of which are based upon information derived from the lawgiver who founded them and in which there is no room for reason except in so far as is necessary for the deduction of practical applications.

In these words the historian and sociologist Ibn Khaldūn[1] expresses his view of the division of the sciences, a view which is the reflection of that generally adopted in Islam. The earliest Islamic acceptance of the word *'ilm* ("knowledge") did not however extend beyond the limits of what was known to Muhammad and his interpreters who were nearest to him in time. To them the results of Greek philosophy were not as yet familiar and their conception of science was therefore a very different one. An aphorism attributed to the Prophet declares that "Knowledge is twofold; knowledge of religions and knowledge of bodies",[2] the face value of which is that knowledge lies in theology and medicine,[3] although it has been interpreted to mean that science is divided into two branches dealing respectively with the abstract and the concrete.

It is clear from these classifications that in Islam, science, in the sense of "natural" science, far from being contrasted with religion is not at all to be distinguished from it, and includes it within its scope. From the point of view, indeed, of the ordinary believer who is convinced that Islam covers the whole of life, his

[1] *Prolégomènes*, ed. Quatremère, II, 385.
[2] *Al-'ilm 'ilmān, 'ilm al-adyān wa-'ilm al-abdān.*
[3] Cf. Ibn Abi Uṣaybi'a, *'Uyūn al-anbā*, ed. A. Müller (Cairo, 1882), p. 2.

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religion, as being the greater, includes all that is known as natural phenomena. This aspect of the matter is illustrated by the well-known legend of the Caliph Omar and the library at Alexandria, which he ordered to be destroyed because the learning which it represented was either to be found in the Koran or it was not; in the one case it was superfluous and in the other harmful.[1] The story is almost certainly apocryphal,[2] but it represents the spirit of certain classes of Muslims who were prepared to maintain that the whole of knowledge was contained in the Koran or the Traditions of the Prophet; an attitude parallel to that of the Rabbis who declared that all wisdom was to be found in the Torah. According to Ibn Ḥazm,[3] "Any fact whatsoever which can be proved by reasoning is in the Koran or in the words of the Prophet, clearly set out." Those who took up this attitude declared that since Islam superseded all the religions that went before, it also abolished all the accumulated learning that was associated with them.[4] But this unbalanced view was adopted only at a comparatively late stage in the history of Islam, when the predominant influence of the *'ulamā* had made it rigid and exclusive. If the fact had been otherwise it is difficult to conceive how the study of Greek science could have been so eagerly pursued and so generously encouraged as it was under the ninth-century Abbasid Caliphs at Baghdad, at the courts of the Persian rulers of that century and the next, in Egypt under a number of the Fāṭimid Caliphs and in Spain under the Umayyads; for in all these places Islam was sternly and sometimes fanatically maintained as the only true religion.

In the earliest stage of its history, the faith was engaged in establishing itself and could not have permitted any recognition of so distracting and unsettling a study as that of Greek philosophy,[5] even if the materials had been available. But with the

[1] See Gibbon, *Decline and Fall*, ch. LI (ed. Bury, V, 452 ff.).

[2] Ibn Khaldūn, *Prolégomènes*, III, 89 f., ascribes the event to the conquest of Persia, without specifying the locality of the library.

[3] *Kitāb al-Fiṣal* (Cairo, A.H. 1317), II, 95.

[4] Cf. Ibn Khaldūn, *ibid.* II, 387.

[5] Yet even during that period, it is reported, the Umayyad prince Khālid ibn Yazīd ibn Mu'āwiya studied alchemy, medicine and astronomy with a Greek monk. (See Ibn Khallikān's life of the prince.) Ibn al-Nadīm, *Fihrist*, ed. Flügel (Leipzig, 1871), I, 354, mentions only his interest in alchemy, "the Art" (*al-ṣan'a*); cf. Qiftī, *Ta'rīkh al-ḥukamā*, ed. Lippert, p. 440. Some doubt was thrown on the report by J. Ruska, in his *Arabische Alchemisten*, I (Heidelberg, 1924).

emergence of the Mu'tazilīs, who sought to establish their faith on a rationalist basis, outside influences began to be felt. It became impossible to exclude from consideration the ideas of the Greeks and others who had elaborated "philosophic" or "scientific" systems based on observation and reason. Nevertheless, even after the existence of philosophy had been recognized, *'ilm*—which corresponds in its original significance to the Latin *scientia*—continued to embrace theology and the learning which is concerned with the fundamentals of Islam. Apart from a small number of investigators inspired by Greek philosophic ideals, the Muslims who engaged in the pursuit of science did so, like the Hebrews, in order to discover in the wonders of nature the signs and tokens of the glory of God.[1] But those who, like the Greeks, were eager for abstract truth for its own sake, did not cease to remain true believers; so that the philosopher Avicenna, whom the learned Shahristānī places for discussion among the *Ahl al-Ahwā* (those who stood outside positive religion and evolved their ideas out of their own "desires"), confesses in his autobiography that he repaired to the mosque for prayer and inspiration when he was at a loss in the working out of his problems.[2]

It is necessary now to examine in greater detail the Islamic conception of "science". The prime division, it has been seen, is into the religious and the secular studies. The former are concerned with the Koran, the *ḥadīth* and theology, the language of which is Arabic. For that reason they are called *'Ulūm al-'Arab*, "The Arab Sciences", while the secular sciences, being derived mainly from foreign (Greek) and ancient sources are known as *'Ulūm al-'Ajam*, "The non-Arab Sciences" or *'Ulūm al-Awā'il*, "The Sciences of the Ancients".

Of the "Arabic" or "traditional" branches of science, that which made the Koran its subject-matter was evidently of paramount importance. The language and thought of the sacred book, regarded as literally and verbally the word of Allah, were made the object of intense study and investigation, for every word and letter was endowed with significance. This led to research into the Arabic language and in particular into the vocabulary and grammar of the dialect spoken by the Prophet's own tribe of the Quraysh.

[1] Cf. Koran 50[6], with which cf. Psalms XIX[2], and see also Job, XXXVIII ff. See further Qifṭī, *ibid.* p. 50, ll. 3 ff. [2] Qifṭī, *ibid.* p. 415, ll. 6 ff.

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As an aid to this study, collections were made of surviving specimens of ancient Arabic verse, which had been the more easily retained in the memory by reason of their rhythm and rhyme, and to these verses reference was made for the explanation of Koranic and other words which were unfamiliar or rare. From other sources, likewise, materials which had a bearing on the significance of words were assembled, ultimately to form the basis of dictionaries. Grammar was associated with lexicography and formed an important subject of study, particularly in Iraq, where the schools at Baṣra and Kūfa became famous. Both these disciplines were ancillary to the study of Koranic exegesis.

Next in importance to the Koran as a subject of study, and, for the practical purposes of Islam as a religion, equal with it in importance, came the Traditions of the Prophet. They not only formed one of the "roots" of the *fiqh* but provided most of the materials for Muhammad's biography. The work of writing his life and describing his campaigns was early undertaken, and its ramifications included accounts of the various peoples, Arab and foreign, with whom he came into contact. His companions too became the objects of research, so that genealogy, which had been a species of knowledge greatly esteemed in pre-Muslim days, was able to retain its importance, but with the difference that now it was relationship with the Prophet or his tribe of the Quraysh which investigators sought to establish. The rise of the early Caliphs and the beginning of foreign conquests gave the first impulse to more general history, which was not confined to the Arabs but concerned itself with all those nations with whom the Prophet's victorious successors were concerned.[1]

At the same time more general literary pursuits, such as poetry (a survival from pre-Muslim days), rhetoric and *adab*, which latter corresponds in a general fashion to *belles lettres*, were not neglected, particularly since, as the influence of Islam grew, their subject-matter drew increasingly upon apostolic tradition or was treated in such method as to provide religious edification. By Ibn Khaldūn[2] they are included with lexicography and grammar

[1] Cf. the contents of Khwārazmī's *Mafātīḥ al-'ulūm*, composed in A.D. 976, and of the *Fihrist* of Ibn al-Nadīm, composed in A.D. 988 (ed. Flügel, Leipzig, 2 vols., 1871–2). For a description of these works see E. G. Browne, *Lit. Hist. of Persia*, I, 378 ff.

[2] *Prolégomènes* (text), II, 385.

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amongst the philological sciences which are the necessary preliminaries to the study of the Koran and are therefore regarded as belonging peculiarly to the "Muslim" sciences. Based upon the Koran and *ḥadīth* are the science of the principles of the *fiqh* and that of the practical applications of them, and, finally, that of *kalām*, or scholastic theology, which is concerned with the nature of God, with His manifestations, the Resurrection, the reward of Paradise and the punishment of Hell, with Destiny, and with the rational proofs of them all.

Although the primary concern of all these studies was the elucidation of the religious and legal content of the Koran, they incidentally throw light upon the scientific conceptions, in the more technical sense, of the Prophet and of those who undertook to interpret his words. There were already in existence amongst the Arabs of the *Jāhilīya* a number of arts and crafts such as horse-breeding, farriery and camel-rearing, the technical terminology of which was the result of long study. There was also a body of locally acquired knowledge concerning the fixed stars, the movements of the planets and the changes of the weather, all carefully observed for the purposes of travel, whether peaceable, as when flocks and herds were being moved to fresh pastures, or warlike, as when raiding was afoot. In a like class were the names of the plants and wild animals of the desert. A further branch of knowledge was that of local and tribal history, with which was associated the study of genealogy, of considerable practical importance in matters of inheritance, and even more when there was a question affecting prestige, either tribal or individual. Such lore as this provided the background of the Prophet's teaching.

In the Koran the aspects of Nature which are mentioned are usually associated with descriptions of the Creation, and the reference to them is of a rhetorical character. It may, however, be gathered that the Prophet conceived of the universe as geocentric. The earth itself also is constantly spoken of as having been "stretched out" at Creation[1] or "spread out" as a carpet,[2] whence it may be inferred that the Prophet conceived of it as flat,[3] although orthodoxy denies this.[4] As a rule the earth is spoken of in the

[1] Koran 79^{30}, 84^{3}. [2] *Ibid.* 51^{48}, 71^{18} f. [3] Cf. *ibid.* 78^{6}.

[4] The commentator Baydāwi, on Koran 2^{20}, declares that it does not follow from the Prophet's utterances that he thought of the earth as flat, for the extent of the surface of the globe is vast enough to justify the idea of its being "spread out".

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singular, but in one passage[1] it is declared that Allah created the earth to correspond with the seven heavens[2] with which before Creation it formed one piece.[3] On to the earth the mountains were "cast down" to act as tent-pegs[4] in order to hold it in position and prevent its movement,[5] presumably upon the primeval waters,[6] and on the surface of the earth also were created "the two seas", the one fresh and the other salt,[7] which meet but are yet kept unmingled with one another.[8] They would appear to have been distinct from the primeval waters over which floated the Throne of Allah.[9]

Over the earth the sky is built up as a roof[10] and is held aloft by Allah's power without the need for any supporting columns.[11] It consists of seven heavens,[12] firmly constructed[13] in layers one above the other.[14] No hint is given of the estimated distance between them, or of the distance between the heavens and the earth, but the commentators attribute to the Caliph Omar the opinion that the latter distance is equivalent to that which lies "between the east and the west" and would be a five hundred years' journey at the pace of a traveller upon a level road.[15]

[1] 65^{12}.
[2] Cf. Bayḍāwī on 6^{1}, 39^{67} and Ṭabarī, *Ta'rīkh*, I, 38.
[3] Koran 21^{31}.
[4] *Ibid.* 78^{7}.
[5] *Ibid.* 21^{32}, 31^{9}, 16^{15}. Bayḍāwī, on the last verse, remarks that before the mountains were created on the earth, it was a smooth sphere and that, true to its spherical character, it revolved like the heavens, or moved for other causes, even the slightest. When the mountains were created in it, the "sides", i.e. the "cardinal points", of the earth were differentiated and the mountains by their weight settled towards the centre and became equivalent to tent-pegs to prevent its moving.
[6] The commentators speak of the *Nūn* (the "Fish" of Babylonian mythology) which they distinguish from the waters beneath. Cf. Ṭabarī, *Ta'rikh*, I, 49 f.
[7] Koran 25^{55}.
[8] Koran 55^{19}, 27^{62}, 35^{13}.
[9] *Ibid.* 119. Ṭabarī, *Ta'rikh*, I, 37 f., *Tafsīr*, XII, pp. 4 f., quotes an opinion describing this as the "surrounding" sea which lies about the heavens and the earths and divides off the seven "earths" from each other.
[10] Koran 21^{33}.
[11] *Ibid.* 13^{2}.
[12] *Ibid.* 23^{16}, 2^{27}.
[13] *Ibid.* 78^{12}.
[14] *Ibid.* 71^{14}, 23^{16}, 67^{3}, 2^{27}. The heavens began as vapour. Traditionally, the lowest heaven is made of green emerald, the second of white silver, the third of red coral, the fourth of white pearl, the fifth of red gold, the sixth of yellow coral and the seventh of light. (Mas'ūdī, *Murūj al-dhahab*, I, 47 ff.) Commenting on Koran 2^{27} Bayḍāwī reconciles the Koranic conception with the Babylonian-Ptolemaic theory of nine spheres by declaring that there is a doubt about the latter, but alternatively that if it is true, the *'Arsh* and the *Kursī* (both meaning the "Throne") make up the nine.
[15] Ṭabarī, *Ta'rikh*, I, 2822.

In separate heavens float the sun and the moon,[1] and in the lowest heavens are other luminaries,[2] presumably the fixed stars and the planets.[3] The sun journeys each day to an abode determined for its rest,[4] "as though the sun had a halting-place",[5] and to reveal the splendours of the night the day is stripped away from it as though it were a curtain.[6] The moon has amongst the signs of the zodiac[7] its appointed stations, to which it comes on successive nights,[8] but the heavens as a whole return after each revolution to the same positions,[9] and the sun may not outstrip the moon nor the night the day in their regular succession.[10]

In the heavens is stored up the rain[11]; the clouds, driven by the winds, cover the sky, and by means of them and through their interstices the water pours down to fertilize the earth.[12] Hail also descends from mountainous clouds sent down from the heavens,[13] clouds like those which harbour "darkness, thunder and lightning".[14]

Of the ultimate constitution of matter the Koran itself has nothing to say, although the commentators, as will appear, make their own inferences from the text. But in his revelations the Prophet specifically declares that all living things were created from water,[15] although man, according to another idea, was created of clay[16] and the *jinn* of fire.[17]

By the commentators of the Koran the question of the composition of matter was treated in the spirit characteristic of the ancient sages who aimed at presenting knowledge in the form of concise aphorisms put into the mouths of the heroes of the people and given the authority of great names. Thus there is a story that,

[1] Koran 36[40], 21[34], 71[15]. [2] *Ibid.* 67[5]. [3] *Ibid.* 81[15 f.].
[4] *Ibid.* 36[38]. [5] Bayḍāwī *ad loc.* [6] Koran 36[37].
[7] *Ibid.* 15[16].
[8] *Ibid.* 36[39]. The phases of the moon are appointed in order to acquaint men with times and seasons (*ibid.* 2[185], 10[5]).
[9] *Ibid.* 86[11]. [10] *Ibid.* 36[40]. [11] *Ibid.* 15[22].
[12] *Ibid.* 30[47-49], 2[159], 7[55]. "There is, under the Throne, a sea whence descends the sustenance of all living creatures. What God wills rains down from one heaven to another until it reaches the place called *al-Abram*. And God sends to the wind which bears it to the cloud, and that sifts it down." (Mas'ūdī, *Murūj*, I, 49 f.)
[13] *Ibid.* 24[43].
[14] *Ibid.* 2[18]. Bayḍāwī on this verse says, "It is known that the cause of it [thunder] is the collision of the masses of the clouds when the wind drives them together."
[15] *Ibid.* 21[31], 24[44], 25[25]. [16] *Ibid.* 23[12] ff., 35[12]. [17] *Ibid.* 15[27].

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in the course of Omar's wars against the Greeks, the emperor wearied of battle and engaged the Caliph in a duel of wits. In one bout he sent his adversary a bottle with the request to him to "fill it with all things". Omar replied by sending back the bottle filled with water and accompanied by a message which said that it contained "all things in the lower world".[1]

According to Bayḍāwī,[2] God could create absolutely, *ex nihilo*, as He created the heavens and the earth, or from matter already existing, as He created all that lies between the heavens and the earth. The new creation need not be of the same genus as that from which it was derived; thus Adam and the animals were different from the matter of their origin (water or clay); and living creatures might come from the male alone, as Eve from Adam, or from the female alone, as Jesus from Mary, or from the male and female together, as in the generality of mankind, In this connection it may be observed that the Koran speaks of human beings that were transformed into apes and swine.[3]

The Koranic declaration (of Biblical origin) that the world was created in six days[4] was discussed by the Muslim commentators in much the same way as the Rabbinical commentators discussed the original of the statement in the Book of Genesis, and the conclusion reached concerning the age of the universe and the probable period of its duration (namely, six or seven thousand years in all) was little different.[5]

Simultaneously with the rise of the Mu'tazilīs[6] and their interest in a rational explanation of their beliefs, a desire for knowledge beyond that supplied by the "Arabic" sources of the Koran and the *ḥadīth* began to grow in Islam. The effect was that under some of the early ninth-century Abbasids, Greek learning as contained in the philosophy and "natural science" of Aristotle,

[1] Ṭabari, *Ta'rikh*, I, 2822. Mas'ūdi, *Murūj*, I, 47, states that men of science were agreed that the first thing God created was water. The reason is an obvious one.

[2] On Koran 5^{10}.

[3] *Ibid.* 2^{61}, 5^{65}.

[4] *Ibid.* 41^{8-10}, 50^{37} ff.

[5] Cf. Ṭabarī, *Ta'rīkh*, I, 8 ff.

[6] The "seceders"—a sect particularly active during the reign of the Caliph Ma'mūn (813–33). They differed from the orthodox theologians in holding that the Koran was the creation of Allah and was not co-eternal with Him, also that his attributes had no separate entity.

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the mathematics of Euclid and the medicine of Hippocrates and Galen was made available, in translation, to the lettered amongst Muslims who interested themselves in such matters. The Koranic conceptions of "natural" science had indeed been expanded and elaborated by the transmitters of *ḥadīth* and by those who regarded the description of worldly phenomena as a vehicle for the reporting of edifying anecdotes concerning the Prophet and his companions or others of high rank in the hierarchy of Islam. But the more philosophic standards and methods of the Greeks had their attraction for those whose conception of religion did not exclude the possibility of studying the products of foreign thought. The imported ideas spread rapidly, and those of the learned who had a taste for theory and speculation turned to them eagerly, not as to revealed truth but in the hope of finding answers to questions newly arisen in their minds and not touched upon in the works available to them.

The most famous name in the early period when Greek influences began to work upon Islamic thought is that of al-Kindī, "the Philosopher of the Arabs", who died about A.D. 850. His work, however, is, except for a negligible quantity, not available in the original and we may turn, as an alternative, to the work of his contemporary, the Mu'tazilī Jāḥiẓ of Baṣra, who died in 255/869. He was an enlightened *mawlā* who read widely and whose discursive writings bear frequent evidence of an independent mind working upon traditional materials in the endeavour to find a satisfactorily rational explanation of the universe. In his *Kitāb al-Ḥayawān* ("Book of Animals")[1] the ostensible purpose of which is to be a text-book of zoology, he roams over a vast number of subjects, in the course of discussing which he discloses a knowledge of the Aristotelian doctrine of the four elements (*al-arkān*) which go to compose the sublunar world; namely water, earth, air and fire. He accepts this doctrine and, still under Aristotelian influence, divides the universe into two parts, that which grows (and has life) and that which does not grow. That which grows he subdivides into animals and plants, after which he devotes himself to the various genera of animals. For them he creates four classes—corresponding in general to the Aristotelian classification but reached by applying a wholly divergent system

[1] Ed. Cairo (7 parts), 1325/1907; part i, p. 14.

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of differentiae[1]—in which they are arranged according as they walk, fly, swim or move along on their bellies. He is aware that the classification is not a satisfactory one, for he knows, for example, that creatures which fly also walk, but he claims that he will not be misunderstood, because those creatures which walk and do not fly will not be called flying things. The class which walks is further subdivided by him into four genera, namely, men, domestic animals, wild animals and creeping things; and the division stands, as being comprehensible "to hearers of this speech and those who have this tongue", even though the things that creep may also come into the classes of the domestic animals or of the wild animals.[2]

In another part of his discursive work on animals, the author returns to discuss the question of the four elements. Some of the "materialists" (i.e. the secularist philosophers), he says, declare that the world is composed of the four elements: heat, cold, dryness and fluidity (all existing things being compounded of these four, which they call "substances"[3]); others, he says, declare that the four elements are earth, air, water, fire, the other four being mere attributes of these essentials. The question was one which greatly exercised his contemporaries, and those who held that the "natural" bodies were heat, cold, dryness and fluidity considered that fire, earth and the rest of the series were their compounds.[4]

The spirit of the science of the day may be appreciated from Jāḥiẓ's exposition of the nature of compounds. As the basis of his

[1] Cf. W. D. Ross, *Aristotle* (London, 1923), pp. 114–17.

[2] *Ḥayawān*, I, 13 f., IV, 90. [3] *Ajsām*.

[4] The *Firdaws al-ḥikma* ("Paradise of Science"), written by 'Alī ibn Sahl Rabban al-Ṭabarī about 850 propounds this view and also the view that these compounds (the "natural" qualities) had within them the power of being changed into each other. Thus water was potential air, air was potential fire, and so on through the series. The result of a change was not absolute in so far as quantity went but was only so in respect to the nature of the substance. The example is given of water, which turns to "air" ("e.g. in the hot baths where the water rises as 'air' to the roof and there condenses to form water again; also the fire of a lamp newly quenched may turn into 'air' and this back into fire"). See the edition by M. Z. Siddiqi (Berlin, 1928, pp. 11 ff.). Al-Kindī is said to have written a treatise on the Aristotelian theme that the heavens were composed of a fifth "natural quality" (*ṭabī'a*) different from the four sublunar ones. (Ibn Abi Uṣaybi'a, *'Uyūn al-anbā*, I, 211.) About a century later, Mas'ūdī took Aristotle's "fifth" essence to refer to the series heat, cold, etc., and not to the series earth, air, etc. See *Kitāb al-Tanbīh*, ed. M. J. de Goeje, Leyden, 1894, p. 8.)

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discussion he takes the luminous and combustible substances and proceeds to inquire whether the fire in them was actually in existence before coming into view and whether in that case it existed alongside or within the body in which it appeared. He goes on then to inquire into the means of its coming into being if it is not hidden within the body; also how it is that air transforms fire and wood into charcoal, if the fact of transformation be admitted and if the fact of the persistence of qualities (accidents) be proved. Further he inquires into the constitution of the combustible matter that appears in trees, and into the sparks that appear from stones, into the colour of fire and other allied questions.[1]

Another example of the critical character of the man, less probably of his age, is to be found in his discussion concerning the existence of the fabulous bird known as the '*anqā*, which corresponds in some of its features to the phoenix. There are people, he says, who hold that the bird exists, but he declares that to him the thing is so much "red sulphur", i.e. a fiction. Whilst on this subject of fabulous reports he discusses the question of the rhinoceros and of the birth of its young, about which Indians make statements which, he says, men of science would sweep aside as nonsensical if the Indians did not so persistently repeat them. They are to the effect that the young animal puts out its head from the mother's belly to feed on the surrounding vegetation before being actually born and withdraws it again when it is satisfied. Jāḥiẓ remarks on this, "I do not consider this to be impossible, nor outside God's power. . . . We do not find that the Koran denies it nor that *ijmā'* rejects it; neither do I therefore venture to reject it, but my heart strongly inclines to refuse belief in it. This is something which man cannot know by analogy, nor know at all except by actual seeing."[2]

Most of the Muslim philosophers of note confined themselves more rigidly to the Aristotelian scheme[3] and were content to follow the Stagirite without substantial modification from other sources. A part of his system, which accorded well with their liking for analysis and subdivision, was his classification of the sciences. This consisted primarily of a division into two groups, the theoretical and the practical, in the first of which he included

[1] *Ḥayawān*, part v, p. 2 ff. [2] *Ibid.* vii, 40 f.
[3] Cf. Qifṭī, *Ta'rīkh al-ḥukamā*, p. 29, ll. 6 f.

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first philosophy (metaphysics), physics and mathematics, while in the other were gathered those arts or sciences which comprehend action in addition to reasoning. Subsequent elaboration divided the latter group into the practical, which have no other result than the action itself, and the constructive or artistic, which leave as their result, when the action is completed, some substantial product.

Of the learned in Islam, the first, according to tradition,[1] to concern himself with the question was the Turkish *savant* Abu Naṣr al-Fārābī (died at Damascus in 339/950), who, as his name indicates, was a native of Fārāb in Transoxiana. In his work entitled *Iḥṣā al-'ulūm* ("The Enumeration of the Sciences") he groups the sciences with which he proposes to deal or has dealt, as follows: I. The science of language (in seven parts); II. The science of logic (in eight parts); III. The science of mathematics (in seven main parts, which are: arithmetic, geometry, optics, astrology, music, "weights" and mechanics); IVA. Theological and natural science (in eight parts, which are: that which all natural bodies share in common, the simple bodies, the coming to be and passing away of bodies (*de Generatione et Corruptione*), the beginnings of "accidents" and changes which concern the elements, the bodies compounded of the elements, the mineral bodies,[2] plants and animals); IVB. The science of "theology", comprising politics, *fiqh* (law) and *kalām* (scholastic theology).[3]

In another work, *De Ortu Scientiarum*, which is ascribed to him but which exists only in a Latin translation, there is a brief exposition of his philosophy in a rather different form. This declares that nothing exists but substance, accident and the Creator of substance and accident. Accidents may be perceived by the senses; substances only by reason, accidents being the means of their being perceived. Natural science deals with the occasions and causes of changes in substances; it is the science of action and passivity. The origins of all substances under the sphere of the moon[4] lie in

[1] Cf. Qifti, *ibid.* pp. 277 f.

[2] Al-Fārābī would appear to be the originator of the division of substances into mineral, vegetable and animal. Aristotle contented himself with treating the "soul-less" substances as a background to the rest.

[3] M. Bouyges, "Sur le *de Scientiis* d'Alfarabi" (*Mélanges de l'Université Saint-Joseph*, IX (1923–4), 41–96).

[4] He follows Aristotle strictly in believing that there is a fifth element (the quintessence), of which the sky is composed.

the four elements, fire, air, water, earth, from the four qualities of which, namely heat, cold, fluidity (moisture) and dryness, arise the accidents as well as action and passivity. Out of these roots, together with the four mathematical sciences (*al-'ulūm al-riyāḍīya*) of numbers, mensuration, astronomy and music, arises all knowledge under the sphere of the moon. The component parts of natural science, as here given, are as follows: judicial astrology (*de judiciis*), medicine, divination (*de nigromantia*), (interpretation of) visions (*de imaginibus*), agriculture, navigation, alchemy ("which is the science of transforming things into other species") and optics (*de speculis*).[1]

Al-Fārābī's great successor Ibn Sīnā (Avicenna) (d. 1037) went back beyond him to Aristotle himself, although making certain changes which accorded with his special purposes. In a short treatise[2] which he devoted to the subject of the classification of the sciences, he makes a primary division of wisdom or philosophy (*ḥikma*)[3] into two parts, the one theoretical or speculative and the other practical. The aim of the theoretical is the acquisition of established beliefs concerning existing things whose existence in no wise depends upon man's activity; its purpose indeed being merely the forming of reasoned views (*ra'y*), as, for example, in the "science" of belief in the unity of God or in the "science" of predestination (*qisma*). In the practical the aim is not merely the acquisition of settled beliefs concerning existing things but rather the acquisition of reasoned views in matters by which a man may attain to what is good; it is opinion acquired with a view to action.

A different division is into three parts, namely, the lower science, which is called "natural" science (*al-'ilm al-ṭabī'ī*), the middle science, which is called "propaedeutic" (mathematical)

[1] Clemens Baeumker, *Alfarabi, Ueber den Ursprung der Wissenschaften* (*De Ortu Scientiarum*), in *Beiträge zur Geschichte des Mittelalters*, XIX, iii. Munster i. W., 1916.

[2] *Risāla Taqsīm al-'ulūm*, British Museum MS. Add. 16,659, fol. 342 b–345 a.

[3] He defines it as "a speculative art whereby a man may attain to a realization of the purpose of existence as such, and also of the end to which his own actions should be directed in order that his soul may be ennobled and perfected and that he may become wise and understanding, conforming with the existing world but preparing for the ultimate felicity of the next world, in so far as lies in human power".

science (*al-'ilm al-riyāḍī*), and the upper science, which is called "theological" science (*al-'ilm al-ilāhī*).

"Original" natural science is subdivided into two parts, of which the first,[1] which may be regarded as the root (or principle), is concerned with the qualities possessed by all substances in nature—namely matter, form, motion, character and causes (or conditions of production), whether to an end or not. The second part, which may be regarded as the branch or derivative, is that whereby there are made known the conditions of those substances which are the essential constituents of the world—namely of the heavens and what is in them and of the four elements and their natural properties, their movements and their stations.

The derivative part is subdivided into the various "departmental sciences"; medicine, astronomy, physiognomy, "interpretation of ideas" (*ta'bīr*), magic (*'ilm al-ṭilismāt*) and alchemy.

Intermediate in time between Al-Fārābī and Avicenna come the so-called *Ikhwān al-Ṣafā*, "The Brethren of Purity", an "academy" or society which flourished at Baṣra in the latter part of the fourth/tenth century. From their work, consisting of a number of treatises covering the whole field of contemporary knowledge, it may be gathered that they were rationalists interested in educating their fellow-Muslims in ideas of the universe which were not to be gathered from orthodox doctrine. On this and other grounds—such as that their work is mainly anonymous—the assumption has been made that they were a group of Shī'ite or Mu'tazilī origin inspired by a definitely political object, namely, the overthrow of the Abbasid dynasty. It is stated that they derived their title[2] from their declaration that the law (*sharī'a*) had become defiled with ignorant teachings and polluted with errors and that the only way to "purify" it was by means of philosophy.

Other members of their faith were not disposed to agree with the "Brethren" and characterized their treatises as superficial efforts to cover every branch of knowledge without satisfaction or efficiency, and containing falsehoods and errors in abundance. When the treatises were submitted to Abu Sulaymān al-Manṭiqī (the Logician) he returned them with very unfavourable

[1] This corresponds to Aristotle's First Philosophy.

[2] In full it is *Ikhwān al-Ṣafā wa Khullān al-Wafā wa Ahl al-'Adl wa Abnā' 'l-Ḥamd*, "Brethren of Purity, Friends of Honour, Men of Justice and Sons of Praiseworthy Conduct". *Ikhwān al-Ṣafā, Rasā'il*, ed. Cairo, 1928/1347, 1, 1.

comment, declaring that the authors had attempted to conceal philosophy under the cloak of the *sharī'a*, and had failed, even as cleverer men before them had failed. When asked his reasons for his opinions he replied that the *sharī'a* was derived from Allah by means of an inspired intermediary and that submission to its contents was demanded without question of why, or of how. The talk of an astrologer-astronomer (*munajjim*) about the influences of the stars and the movements of the heavens, he declared, has no place in the *sharī'a*, nor has any discourse of any "natural scientist" observing their phenomena and the facts concerning heat, cold, fluidity and dryness, or concerning what is the agent and what the patient and what their unions and antipathies are, nor is there any place for the discourse of geometrician or logician. How therefore, he asked, could the "Brethren" permit themselves to claim that they could combine philosophy with the *sharī'a* despite the fact that others beside them might lay claim to their methods; men, for example, like the enchanter, the alchemist, the talisman-maker, the interpreter of visions and the magician? If all these plied their professions lawfully Allah would have declared them lawful and the Giver of the *sharī'a* would have made use of them to make good any deficiency there may be in it. But He did not do so. On the contrary, He denounced them all and prohibited the Muslim from concerning himself with them, saying that he who consults a wizard or soothsayer seeks to discover God's secrets. Moreover, Allah sent a perfect religion by His Prophet and left no need, after the clear exposition provided by inspiration, for any recourse to the expositions of reason. Muslims in the past, he concluded, had been able to discuss their religious differences and difficulties without recourse to philosophy, just as Jews, Christians and Magians had been independent of it for the purposes of their religion, and there was no need now to apply to it.[1].

These were reactionary views of the kind which, with certain reservations, Ghazālī about a century later set himself to combat in his *Tahāfut al-Falāsifa*[2] ("The Confusion of the Philosophers") and other writings. It was in the face of such opinions

[1] Qiftī, *ibid.* pp. 82 ff.

[2] This was itself combated by the twelfth-century philosopher Averroes in his *Tahāfut al-Tahāfut*. Cf. M. Bouyges, *Bibliotheca Arabica Scholasticorum*, III (Beyrouth, 1930); and the translation by S. van den Bergh, 2 vols. (London, 1954).

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that the Brethren did their work, which was undertaken in an endeavour to teach Muslims some of the facts, derived from foreign sources, concerning the world of phenomena. It is clear from their object that the treatises[1] were not intended for professed *savants* but for a more popular audience. They nevertheless cover a wide field and illustrate what the Brethren regarded as the capacity for scientific knowledge possessed by their better informed fellow-members of Islam in the fourth century of its history. The original Aristotelianism of the Treatises is strongly coloured by neo-Platonism and they are marked by endeavours to harmonize the Greek with the Muhammadan thought, but the source of their inspiration remains clear throughout.

The first treatise (on Number) states in an introductory paragraph the general scheme of the whole and declares that philosophy, or science, is divided into four parts, comprising respectively the mathematical, the logical or dialectical, the "natural" and the theological sciences. The mathematical group is made up of arithmetic, geometry, astronomy and music, the division later adopted by the Schoolmen, to whom it was known as the *quadrivium*. In the chapter on arithmetic the main interest lies in the theory of numbers. They are represented as being in four grades, namely, units, tens, hundreds and thousands; they are not so of necessity, as part of the "nature" of number, in the way that numbers must be either odd or even, but they have been so classified by the sages in order to make numerical matters accord with "natural" matters, most of which were arranged by Allah in fours, e.g. the four natural qualities (*ṭabā'i'*)—heat, cold, etc., the four elements (*arkān*)—fire, air, etc., the four humours—blood, phlegm, yellow bile and black bile[2]—the four seasons of the year, the four "directions" (points of the compass) and the four classes of created things—minerals, plants, animals and man.[3] A description of the special characteristics of the individual numbers forms part of the Treatise; thus that two is the first real "number", three the first odd number, four the first square number, five the first "round" number, seven the first "perfect" number, and so forth up to twelve and beyond. Then come successively a description of the arithmetical processes, a section

[1] Their number is given as either 51 (Qifṭī, *ibid.*) or 52 (*Rasā'il*, 11).
[2] A doctrine derived immediately from Galen. [3] *Rasā'il*, 1, 27.

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on the reason for prefacing the whole work by the Treatise on Number—namely, that this science is present potentially in every soul and only requires study to be known, and a section explaining that the science of Number is a guide to the "science of the soul".

Geometry is the subject of the second treatise and is defined as the knowledge of quantities and dimensions and their properties, beginning with the point and advancing through line and plane to the solid. The two parts of the science are the practical and the theoretical; the first dealing with figures and bodies perceptible by the senses, and the second with the theory of the subject, employing imaginary things such as the line between sunshine and shadow, or the line that may persist in the mind when both sunshine and shadow have disappeared. The use of theoretical geometry is stated to be a guide from the perceived to the imagined and from the concrete to the abstract.

The third treatise is a lengthy one, as befits the importance of its subject, astronomy. Three divisions are allotted to the subject, the first deals with the structure of the heavens, the number of the stars, the signs of the zodiac, the distances of the stars, their size, their motions and whatever else appertains to this subject, which is called '*Ilm al-Hay'a*, "The Science of 'Formation' [i.e. of the heavens]". The second division deals with the calculation of astronomical tables, the making of calendars and similar tasks, while the third has as its subject-matter the prognostication of sublunar events from the revolution of the heavens, the signs of the zodiac in the ascendant and the motions of the planets. This third division of the science is known as '*Ilm al-Aḥkām* ("Judicial Astrology").

The stars are described as spherical luminous bodies, of which 1920 large ones can be perceived by observation. Seven of them are called "planets"; namely, Saturn, Jupiter, Mars, the sun, Venus, Mercury and the moon, and the rest are called "fixed" stars. Each of the seven planets has a sky proper to itself. The skies are spherical bodies, transparent and hollow, nine[1] in number and contained one within the other like the layers of an onion. The nearest of them to us is the sphere of the moon, which surrounds the atmosphere on all sides while the earth is in the centre of the atmosphere. Next to the sphere of the moon is that of Mercury,

[1] Only eight are enumerated; but see below, p. 478.

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beyond which are the spheres respectively of Venus, the sun, Mars, Jupiter, Saturn. Beyond is the sphere of the fixed stars and lastly comes the "all-encompassing" sphere.[1] This last sphere is in constant revolution, like a water-wheel, turning from east to west above the earth and from west to east below it once in every day and night.[2] It moves the other (the orbital) spheres together with the planets, and it is divided into twelve *burūj*[3]—the signs of the zodiac.[4]

The sun annually passes through all the twelve signs of the zodiac, describing an imaginary circle (the ecliptic) in its course. Of the signs,[5] six (Aries, Taurus, Gemini, Cancer, Leo, Virgo) are northern, and while the sun is among them the nights are shorter and the days longer; the other six signs are the southern ones and when the sun is amongst them the nights are longer and the days shorter. The two points where the northern and southern signs meet are known as the "poles" of the zodiacal sphere.[6]

[1] This arrangement of the (orbital) spheres was borrowed by the Brethren from Ptolemy, but appears to have come in the first instance from the Babylonians. The same scheme is given by Mas'ūdī (d. 956) in the *Murūj al-dhahab*, 1, 186 f. In his *Kitāb al-Tanbih* (p. 12) he says that both the ancients and the moderns have disputed about the order of the spheres, Ptolemy Claudius in the Almagest and in his book on astronomy declaring that it was not clear to him whether Venus and Mercury were above the sun or below it, while Johannes the Grammarian reported Plato as having been of the opinion that the sphere of the moon is nearest to us, that of the sun next, then those of Venus and Mercury and then the others in the order set down in the text. In another passage of the *Tanbih* (pp. 9 f.) Mas'ūdī speaks of a sphere outside that of the fixed stars actuating all the other spheres. It was called "The Sphere of the Equator" but, the author adds, it was identified by some astronomers with the sphere of the fixed stars.

[2] "The sphere revolves continuously with a motion inherent in it, and by its motion and that of the stars in it the four 'essential' qualities [heat, cold, etc.] are worked upon and the four elements [fire, water, etc.] are distributed. . . ." By the movements and amalgamations of elements and qualities winds are caused to blow, clouds gather, rain descends and meteorological conditions are set up in the heavens affecting the welfare of living creatures on the earth. (Mas'ūdī, *Tanbih*, p. 9.)

[3] Each *burj* or sign of the zodiac is divided into 30 degrees each composed of 60 minutes. The minute is subdivided into 60 seconds, the seconds into thirds and so continuing.

[4] *Rasā'il*, 1, 73–5.

[5] "The signs are merely a number of fixed collocations which have been given names so that the positions of stars in the universal sky may be determined by them." (Mas'ūdī, *Murūj*, 1, 187.)

[6] "Aristotle and the Indian, Persian, and Chaldean philosophers before and after him believed that . . . the sky was a round, spherical, hollow body turning

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The orbit of the sun in its passage through the ecliptic intersects the orbit of each of the other planets at two points known as the nodes (*jawzahr* or *'uqda*). When the sun and moon together are at one of the nodes of the same sign, and in the same degree of it, the sun is eclipsed. This can occur only at the end of a month, when the moon's position is opposite to (and in line with) that of the sun so that the sun's light is cut off from our vision and we see it eclipsed in the manner in which a cloud passing before the sun will prevent our seeing it. When, however, the sun is at one of the nodes and the moon at the other, the moon is eclipsed; and this can occur only in the middle of a month, for the moon is then in a sign facing that in which the sun lies and the earth is between them, thus preventing the sun's light from shining on the moon.[1]

The sun circles once through the twelve signs of the zodiac in three hundred and sixty-five days and a quarter, remaining in each sign thirty days and a fraction and in each degree a day and a night and a fraction. In the day-time it is above the earth and at night below it. In the summer it is amongst the "northern" signs in the atmosphere and is near to the point which is over our heads,[2] whereas in winter it is amongst the "southern" signs and is lower in the atmosphere and at a distance from the point over our heads. At apogee[3] (*awj*) it is high in the sphere and furthest from the earth, while at perigee it is low in the sphere and nearest to the earth.[4]

At the entry of the sun into four specified and well-known signs of the zodiac the four seasons begin. Thus when the sun descends into the first minute of the Sign of Aries, nights and days are equal in length, the weather becomes equable, winter departs and spring enters, while the entry of summer, autumn and winter is at the descent of the sun into the first minutes of Cancer, Libra and Capricornus respectively.[5]

about two pivots which are the Poles, the one being at the head of Cancer and the tail of the Plough, opposite the point of South, and the other at the head of Capricornus, wherein are stars resembling those of the Plough, opposite the point of the North." (Mas'ūdī, *Tanbīh*, p. 8.)

[1] *Rasā'il*, 1, 78–80.

[2] Lit. "the direction (*samt*, whence 'zenith') of our heads".

[3] Formerly used of any planet, now usually of the moon.

[4] *Rasā'il*, 1, 84.

[5] *Ibid.* 1, pp. 87 f. Mas'ūdī (*Tanbīh*, pp. 14 ff.) gives the length of spring as 93 days 23¼ hours, beginning when 10 days remain of Ādhār (March) and continuing until the twenty-fourth of Hazīrān (June). The length of summer is given as 92 days 23¾ hours, of autumn as 88 days 17$\frac{1}{15}$ hours, and of winter as 89 days 14 hours.

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The last section of the treatise is concerned with astrology, which deals with the influences of the heavenly bodies on terrestrial affairs. Briefly stated the function of astrology is to show that when the planets are in harmonious relationship, affairs in the sublunar world of "Generation and Corruption" go well; and that when the planets are out of harmony affairs go ill. Furthermore, certain conjunctions of the planets point to the occurrence on earth of specified situations and conditions.[1]

In this connection the statement of Ibn Ḥazm of Cordova (994–1064) is noteworthy. According to him[2] the stars have no influence on terrestrial affairs. If there appears to be any such influence it is not that of a dominant and independent force, for the stars are themselves under control and have no ruling power. If it were otherwise, they and their spheres would be able to move as they wished and would not be confined to the single form of motion (the circular) to which they are now compelled. If they have an influence it is no greater than that of fire in the processes of burning or of water in the processes of cooling.

In one of the other treatises (the sixteenth) of their series, the Brethren return to the subject of the cosmos but approach it from a different angle. They quote and expound in it the statement of the ancient philosophers that the universe, the macrocosm, which consists of the seven heavens and the seven earths and what lies between, bears a resemblance to the individual human being, the microcosm, with all his parts and members.[3] The universe is, moreover, endowed with a single spirit which directs the powers of each part of it in the same way that the soul of the individual man directs all his members.

[1] *Rasā'il*, I, 100 ff. Mas'ūdī (*Tanbih*, p. 13) complains that the men of his day who were learned in the science of the skies neglected mathematical astronomy, which deals with the structure and composition of the heavens, and confined themselves to the study of astral influences. He declares that the two branches of the science are inseparable, since the influences are generated by the movements of the planets, and to be ignorant of the one branch means ignorance of the other also.

[2] *Kitāb al-Fiṣal* (Cairo, A.H. 1317), II, 96.

[3] "Man is called the microcosm because his members are divided according to the twelve signs of the zodiac, and the seven planets. In him also is yellow bile, product of fire, black bile, product of earth, blood, product of air, and phlegm, product of water." (Jāḥiẓ, *Ḥayawān*, I, 100.)

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The parts of the universe which compose what is extra-terrestrial are the seven spheres in which the seven planets move, together with the sphere of the fixed stars and the sphere of the outermost heaven, which is the Throne of Allah. Between the lowest celestial sphere and the earth lies the atmosphere. As for the earth, it is—with all that exists upon its surface: mountains, seas, deserts, rivers and lands both inhabited and uninhabited—a single globe, and it is situated, by Allah's favour, at the centre of the universe, in the midst of the air.[1]

This series of spheres, eleven in all, fits closely together, the inner surface of the containing sphere being in immediate contact with the outer surface of that which is contained. There is consequently no empty space or vacuum between them, the cleavage being perceptible only to the imagination. The writer of the treatise declares that those scholars who believe in the existence of a vacuum in the heavens or between the atoms of the "elements" are labouring under a misapprehension, for they imagine, when they see the celestial bodies moving from place to place that there must be empty space there, for otherwise any matter that occupied the space would prevent movement. That would only be true if all bodies were solid and their atoms firmly adherent to one another as in the case of stone or iron. But some bodies are soft, subtile and fluid, like water; and the atmosphere, being of that kind, does not prevent the passage of other bodies.

Beyond the eleven spheres that make up the universe there exists neither matter nor endless vacancy as has been thought,[2] for, says the author of the treatise, it has been shown that no vacuum is possible either inside or outside the universe, "and as for him who claims that there is another body outside the universe, the burden of proof lies upon him".[3]

Except for the earth, which is solid, each of the spheres comprising the universe consists of two concentric hollow spheres

[1] The sun is, however, declared to lie in the middle of the universe because its sphere lies in the middle of the system of spheres (*Rasā'il*, II, 25).

[2] Al-Bīrūnī (d. 1048) declares in his *Kitāb al-Tafhīm*, ed. and tr. R. Ramsay Wright (London, 1934), pp. 44 f., that, "A number of people consider that beyond the eighth sphere there is a ninth entirely quiescent; . . . because the prime mover must not be moved, and it is on this account that they describe it as motionless."

[3] *Rasā'il*, II, 20–4.

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between which is a certain depth.[1] The atmosphere, which surrounds the earth and extends from its surface to the inner surface of the moon's orbital sphere, has a depth seventeen and a half times greater than the earth's diameter, and its diameter is twice its depth. The diameter of the moon's sphere equally is twice its depth, which is also that of the atmosphere. The depth of the orbital sphere of Mercury is one hundred times the diameter of the earth, and twice its depth is equivalent to one-fifth its diameter (i.e. the diameter is ten times the depth). Dimensions of an equally speculative kind are given for the orbital spheres of all the remaining planets. The depth of the sphere of the fixed stars is given as "nearly" twelve thousand times the diameter of the earth and its diameter as twice the depth.[2]

In order to account for the varying positions of the planets in relation to one another a differentiation in the rates of motion of the spheres is assumed. The prime moving sphere—which is itself set in motion by the Divine Spirit—rotates about the earth once in twenty-four hours. The sphere[3] immediately within, being in contact with it, is made to move in the same direction at a slightly lower rate of speed; the amount of difference being one degree in a hundred years. The next sphere, that of Saturn, moves at a lesser rate still, the decrease amounting to two minutes a day, and each successive sphere moves more slowly than the one containing it until the orbital sphere of the moon is reached. That moves most slowly of all and rotates about the earth once in twenty-four hours and six-sevenths of an hour.[4]

The apparent retrograde movement of the planets is explained as follows. When the (five) planets other than the sun and the moon appear at some times to retrograde and at others to halt this does not actually occur, and the phenomenon is due to optical illusion. The reason for it is that each of these planets moves in a small sphere (epicycle) sunk within and compounded with the

[1] The depth and diameter of the earth are the same, namely, 2167 parasangs, and its greatest circumference is 6800 parasangs.

[2] *Rasā'il*, II, 26 f.

[3] The text (*ibid.* II, 29, l 4) reads *kawkab* ("star"), but this would appear to be an error for *falak* ("sphere"). It is the sphere of the fixed stars.

[4] The author claims that his explanation of the differential rates of the planetary motions refutes those "who have no training in scientific study of geometry" and who maintain that the planets move from west to east in a sense contrary to that of "the surrounding sphere" (*ibid.* II, 32 f.).

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thickness of the great one (deferent), so that at one point of its course it touches the outer surface and at another the inner surface. The planet, therefore, is sometimes retreating from the earth (i.e. when ascending) and sometimes approaching it (i.e. when descending). In the upper part of its revolution it appears to be moving amongst the signs of the zodiac in a direction contrary to theirs,[1] and in the lower part it appears to be moving with them, whilst in the actual ascent and descent it appears from the earth to be stationary.[2]

As for the composition of the heavens, the philosophers claim it is of a fifth essence (element),[3] but that means only that the heavenly bodies are not susceptible to the changes wrought by generation and corruption, nor to any change, increase or diminution to which sublunary bodies are liable. It also means that their motion is perpetually circular. Some believe the philosophers' statement to have meant that the skies are different in essence from the sublunary bodies, but that is an error. The evidence of our eyes proves it, seeing that the moon shows the same variation in the capacity to receive light and shade as the earthly bodies, and it throws a shadow as they do. All the heavenly bodies are associated with air, water, crystal and glass in their transparency; the sun and the stars generally are associated with fire in their luminosity and with earth in their dryness. It appears, therefore, that the philosophers meant by their fifth essence no more than that it is the nature of the heavens to move in circles and to be exempt from the changes characteristic of sublunary bodies.

Furthermore the heavens are neither light nor heavy, nor hot nor cold nor moist.[4] The explanation given is that those parts of the universe which are in the rightful places allotted to them by

[1] Lit. "from the first towards the last of them."

[2] *Rasā'il*, II, 36.

[3] See above, p. 467, n. 4.

[4] Mas'ūdī (*Tanbīh*, p. 8) on this question says, "Philosophers both before and after Plato have disputed about the nature of the sky. Some declared that it is composed of the four 'natural qualities' [heat, cold, etc.], the fiery being dominant, but only as it is to be found in bodies naturally and not burning (as fire). Others declared the sky is composed of fire, air and water; earth being absent. Aristotle and most philosophers both before and after him, as well as Indians, Persians and Chaldeans believed it to consist of a fifth 'natural quality' [essence] apart from the others and having neither heat, cold, dryness nor moisture."

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Allah are without the qualities of lightness or heaviness,[1] and thus the heavens, being for ever established in the positions appropriated to them by Allah, are neither light nor heavy. The earth, similarly, being in the place appointed for it at the centre of the universe, is not heavy; nor is the water upon it nor the air above it. And the fire which lies at the top of the atmosphere[2] is not light. But there are parts of the universe outside their own element, which they seek to regain. Thus when earth is in water or in the air it is in a strange element. Meeting an obstacle in the way to its return it exerts effort and is then called heavy. Air within water similarly and fire in air seek to regain their own element. Those things which seek to gain the centre of the universe are called heavy, and those which seek to gain the encompassing sphere (of the atmosphere) are called light.[3]

Coming to the configuration of the earth, the Brethren expand their description of it as a globular body situated in the centre of the atmosphere, and declare that its greatest circumference is 25,455 miles or 6855 parasangs and the corresponding diameter approximately 6551 miles or 2167 (*sic*) parasangs.[4] The centre of the earth is an imaginary point at the middle of the diameter and equidistant from any point on the surface whether the surface at that point be land or water. No part of the surface of the earth can be said to be the lowest, for the lowest part is that which is nearest the centre. The external surface of the earth, namely, the surface in contact with the atmosphere, is upward ("above"), and wherever a man may be standing on the earth's surface he has his feet upon ("above") the earth, pointing downwards to the centre, and his head pointing upwards towards the heavens. He sees but one half of them, the other half being hidden by the earth's curvature, and when he moves from one place to another there

[1] Cf. *Rasā'il*, I, 113 f. [2] See above, p. 484. [3] *Rasā'il*, II, 40 f.

[4] "Authorities concerned with the measurement of the earth and its conformation declare that its circumference is nearly 24,000 miles. That is the full circumference, taking into account all waters and seas; for the waters are curved with the earth and the lines of their configuration correspond. Thus where there is a gap in the earth's curvature [sphericity] either longitudinally or latitudinally, it is filled by a stretch of water of which the longitude and latitude are continuous with those of the land. The extent of a degree was ascertained thus: the latitudes of two cities, Kūfa and Baghdad, were taken, the less subtracted from the greater and the result divided by the number of miles between the two cities. According to Ptolemy a degree corresponds to 66 miles of the earth's surface." (Mas'ūdī, *Tanbih*, p. 26.)

becomes apparent to him part of the sky previously hidden from him.[1]

Of the earth's surface, one half is covered by the great circumambient ocean in such fashion that one-half of each hemisphere is submerged; like an egg half in the water and half out. Of the half which emerges from the water, a half, comprising land adjacent to the equator[2] and to the south of it, is desert, while the other half, lying to the north of the equator is the habitable quarter of the globe. In the northern habitable quarter are seven great seas[3] which are bays and gulfs of the circumambient ocean and the water of which is salt. In this quarter also there are fifteen small seas of varying size. But as for the Sea of the West,[4] the Sea of Gog and Magog[5], the Seas of Zanj[6] and of Zābaj,[7] the Green Sea[8] and the circumambient ocean, they are outside the habitable quarter of the earth.

In this quarter there are as many as two hundred mountain ranges of varying descriptions and extending from the east to the west or from the south to the north, some being in inhabited lands and others in deserts. In this habitable quarter also there are about two hundred and forty rivers, long or short, flowing in various directions. These rivers rise in the mountains, and on their course down to the sea or the marshes supply cities and cultivated lands with water. The surplus water mingles with the seas. In time it becomes vapour and ascends into the air to form the

[1] *Rasā'il*, I, 112 f.

[2] "The equator is an imaginary line going from east to west under the orbit of the head of Aries. Along this line day and night are always equal. There the two poles are directly on the horizon, the one, nearest the pivotal point of Canopus, in the south, and the other, nearest Capricorn, in the north." (*Rasā'il*, I, 114).

[3] The Sea of the Greeks (the Mediterranean), the Sea of the Slavs (? the Baltic), the Sea of Jurjān (the Caspian), the Sea of Qulzum (the Red Sea), the Sea of Fārs (the Persian Gulf), the Sea of Sind and Hind (the Indian Ocean), and the Sea of China (*loc. cit.*). For other accounts, see Yāqūt, *Mu'jam al-buldān*, ed. F. Wuestenfeld (Leipzig, 1866), I, 499 ff.; Ḥamdallāh Mustawfī, *Nuzhat al-qulūb* (tr. G. le Strange, Gibb Series, London, 1919), pp. 221 ff.; *Ḥudūd al-'ālam* (tr. V. Minorsky, Gibb Series, London, 1937), pp. 54, 181 f.

[4] The (Western) Mediterranean. Cf. Yāqūt, *ibid.* I, 504 f.

[5] (?) Mythical.

[6] Below Zanzibar. Yāqūt, *ibid.* I, 501 f.

[7] Java. The text reads, erroneously, *Zānaj*, cf. Yāqūt, *ibid.* sv. *Zābaj*.

[8] A name sometimes given to the circumambient ocean (Yāqūt, *ibid.* I, 504). Apparently not the sea of that name mentioned by Mustawfī. See Mustawfī, *ibid.* p. 224.

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cloud masses which are driven by the winds to the mountain summits and bare heights there to condense and fall as rain. This in its turn forms the rivers.[1]

The habitable quarter has been marked out into seven climes, each like a carpet with its length spread from east to west. They vary in their dimensions, the longest and widest being the first clime,[2] and the shortest and narrowest the seventh.[3] The climes are not natural divisions but are imaginary lines set out by the ancient kings that the boundaries of lands and kingdoms might be ascertainable.[4] Each nevertheless is allotted to the influence of one or other of the planets. The characteristics of the seven climes are, briefly stated, that the first, which is nearest the equator, is the home of the negroes; the next to the northward, containing the cities of Mecca and Medina, is inhabited by men between brown and black in colour; the third, which contains such important cities as Qandahār, Shīrāz, Baṣra, Damascus, Jerusalem, Alexandria in Egypt, Qayrawān and Tangier, is inhabited mainly by brown people. The fourth is the clime of prophets and sages because it is the middle one of the seven and is under the influence of the sun. Its inhabitants are between brown and white in colour and are in constitution and character the best balanced of men. Its cities include Kāshghar, Herāt, Merv, Nīshāpūr, Rayy, Iṣfahān, Baghdad, Mosul and Aleppo. The fifth is the clime of white men, and it passes through the lands of the Turks, across the Oxus, through northern Persia and across the north of the Mediterranean Sea, and after passing through the middle of Andalusia ends in the Sea of the West. The sixth lies in a belt which passes to the north of the "Lands of Gog and Magog", the south of Sagistān (Sīstān), the north of Jurjān, Ṭabaristān and Gīlān, through Armenia to the north of Constantinople and through Macedonia and the middle of North Africa to the Sea of the West. Its inhabitants are between ruddy and white in colour. The seventh

[1] *Rasā'il*, I, 114 ff.

[2] 3000 parasangs long by about 150 wide.

[3] 1500 parasangs long by about 70 wide.

[4] According to Mas'ūdī (*Tanbīh*, p. 34), scholars and sages dispute whether the climes are confined to the region north of the equator, and some hold that they cover the territory both north and south of it. Most are of the former opinion "because of the scanty population of the south". The division of the earth into seven circular climes is known. The fourth and middle one was that containing Babylon.

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and most northerly clime lies in territory of which the names, except for a few like the Sea of Jurjān and the land of Sagistān, are more related to myth than to identifiable realities.[1]

After the treatise on astronomy (including geography), come others on the remaining branches of mathematics, on the speculative and practical arts in general, on ethics and manners, and on the *Isagoge*, the six formulas used in logic and dialectic by the philosophers and bearing the same relation to correct thought as grammar to correct speech.[2] Then follows a treatise introducing the section on the "natural" sciences by a discourse on the common (Aristotelian) factors of "physics", namely, form, matter, motion, time and space. The properties of matter are then described and also the four elements (earth, air, fire, water) together with their compounds, the animal, the vegetable and the mineral.

The first "physical" treatise deals with meteorology and begins by describing the atmosphere. This, it is stated, is divided into three distinct layers, of which that nearest the moon is a fire of the intensest heat and is called the "aether", that which comes next is of the intensest cold and is called the *zamharīr*, and that which is nearest the earth is of moderate temperature in the generality of places and is known as the *nasīm* (the "zephyr"). Although the layers are distinct it is possible for them to interpenetrate.

The atmosphere as a whole is subject to change from a variety of causes which include light and darkness, heat and cold, winds and terrestrial vapours. As consequences of them there arise haloes, clouds, thunder, lightning, rain, dew, snow, hail, rainbows and comets together with such earthly phenomena as the overflowing of rivers and the rise and fall of the tides. The wind is no more than a wave-like motion of the air resembling the motion of waves in the sea. One of the causes of atmospheric movements is the rising of moist vapours from bodies of water on the earth and of dry air from arid regions. They ascend to the intense cold of the *zamharīr* and being driven back from it displace various parts of the atmosphere and so cause the winds.

If there should be a mountain range in the way of vapours of which the pressure happens to be great, the cold of the *zamharīr*

[1] *Rasā'il*, 1, 115–30. [2] *Ibid.* 1, 132–362.

at its summit will drive the vapour down to mingle with any vapours at the foot of the range, their coalescence bringing about the formation of clouds. These rise, and any dry air is turned into wind by their movement while moist vapour becomes water, the particles of which become compacted and form drops of rain. If the ascent of the moist vapour occurs at night, the extremely cold air will prevent its upward movement, condensing it into a wet precipitation such as dew. Any vapour which is permitted to ascend will be acted upon by the extreme cold and, becoming congealed amongst the interstices of the clouds, will turn into ice or snow. These are congealed particles of water which, mingled with particles of air, fall gently to the ground. In spring and autumn, when the clouds are piled high, the topmost layers are in contact with the *zamharīr* and the moisture, becoming congealed in large drops by the great cold, falls as hail, while the lower parts fall as rain.[1]

Lightning and thunder occur simultaneously, but the lightning reaches the vision before the sound to the hearing because the light is "spiritual" in form whereas the sound is "physical". They originate when the cold of the *zamharīr* compresses the dry hot emanations ascending from the earth within the moist vapours that are mingled with them in the atmosphere. The dry emanations are heated and in their effort to escape burst the envelope of vapour, which emits spluttering sounds as moist objects do when fire is piled about them. A rumbling sound, which is diffused in all directions, is thereby set up in the air, and at the same time the dry heated emanations bursting forth from the moist vapours set up an illumination which is called lightning. This occurs in the same way that the smoke from a lamp recently extinguished will light itself if brought near to a flame.[2]

As for the rainbow, that originates in the lowest layer of the atmosphere when the air is moist to saturation. Its position is always vertical, with the curve at the top in proximity to the layer of the *zamharīr*, and it can appear only at the beginning or at the end of the day opposite to the rising or the setting sun. It appears usually as less than a semicircle; when, however, the sun is level with the horizon, the rainbow appears as a complete semicircle. The reason for this is that the centre of the rainbow lies along the

[1] *Rasā'il*, II, 60–5. [2] *Ibid*. 66.

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line drawn (at right angles) from the centre of the body of the sun, and the higher this is in the heavens the less does there appear of the rainbow, which lies below and facing it. The appearance of the rainbow is due to the shining of the sun upon the particles of moist vapour in the atmosphere and the reflection of its rays. The colours are four in number, corresponding to the number of essential qualities, the elements, the seasons, the humours and the colours of flowers and blossoms. The reason is that when the rainbow appears in its full colours it is an indication of the moistness of the atmosphere and of the consequent abundance of grass and herbage, and it is a general token to living creatures of the fertility of the season.[1] The order of the colours is always red above the yellow and blue below the green; and if there is a second bow below the first one the colours will be in the reverse (reflected) order.[2]

The phenomena that originate in the *zamharīr* are the meteors and the falling stars. The matter and substance of them is the dry, subtle, vapour which rises from mountains and arid places. On reaching the line of division between the *zamharīr* and the aether it turns back and the fire of the aether is kindled within it as the fire of lightning is kindled in the dry oil-like smoke compressed in the moist vapour of the cloud, or as fire is kindled in white naphtha.[3] These falling stars appear sometimes to be revolving in a small circle which is itself carried upon the circumference of a large one, for we see them sometimes travelling from the east across the zenith to the west, sometimes from the west to the east, sometimes beginning their journey in the south and passing across the zenith to the north, and in various other directions. They might be imagined by beholders to be balls of cotton set alight and thrown into the air, where the fire burns them away and they throw off sparks until they are consumed.

[1] "The common people say that excess of red points to bloodshed, of yellow to sickness, of blue to famine and of green to fertility."

[2] *Rasā'il*, II, 67 f.

[3] It is an error, say the Brethren, to suppose that the words of the Koran (67[5]), "We have adorned the heaven with lamps and allotted them to be missiles against demons", refer to these falling stars, which some people believe to be cast from heaven into the air, so to fall on to the earth. The meteors, so the Brethren maintain, do not even originate in the heavens, but near the earth, as may be proved from the swiftness of their transit, for if they began in or near the orbital sphere of the moon or higher their passage would take much longer.

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The falling of these stars is only apparent, because the light matter of which they are composed must seek the heights, and their being aflame merely increases their lightness. Those which actually fall to the earth originate in the *nasīm*, the lowest layer of the atmosphere, and are caught and pressed downwards by the clouds. The circular motion of them all is due to the fact that fluid bodies by their nature take a form (namely that of the circle) which offers least resistance. Raindrops in the air take this shape, which is essentially the most perfect.

The comets (literally "stars with tails") that sometimes appear in the sky before sunrise or after sunset, originate in the layer of the atmosphere nearest the moon, the proof being that in their movements they resemble the planets. They are composed of subtle dry and moist exhalations which are condensed by the influence of Saturn and Mercury until they become transparent as crystal. In their course they revolve with the heavens, rising and setting until they are dissipated and vanish.[1]

After the treatise on meteorology follows the section on the composition and formation of minerals, introduced by an explanatory chapter dealing with geology. This begins with some general comments on the characteristics of matter and on its changes. Amongst them are included the changes in the configuration of the earth, such as the gradual transformation of mountains into plains, of plains into the beds of seas and rivers, and of these into marshes, desert sands and mountains.[2] The reason for the existence of mountains and other irregularities in the earth's surface is to prevent the lands being covered entirely by the sea, an event which would occur if the earth were entirely smooth. Rivers and torrents flow down from the mountains but are gradually dried by the desiccating power of the sun, moon and stars. The mountains, deprived of moisture, split and crumble—a process assisted by the action of thunderbolts— and become rocks and stones, gravel and

[1] *Rasā'il*, II, 70–4.

[2] The principle of change also affects the stars. Every 3000 years, the Brethren declare, the fixed stars alter their position and the planets the degree of their apogee and their position with relationship to the signs of the zodiac. The change amounts in 9000 years to one-fourth of the circuit of the sky; in 36,000 years therefore to a complete circuit. Thereby the place of incidence of the planets' rays varies constantly, the result being changes in day and night, summer and winter. Climatic changes in the four quarters of the globe also are to be referred to these celestial changes (*Rasā'il*, II, 80).

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sand. These are carried by rain and streams down to the seas and lakes, upon the beds of which they are deposited, layer upon layer, by the action of waves and storms, until in the course of ages mountains are formed in the depths of the ocean in the same way that hills of sand accumulate in the desert through the action of the winds.[1]

The mountains vary in their composition, some being of hard granite and rock or of smooth stone upon which little vegetation grows, as in the mountains of Tihāma (near Mecca), some of soft rocks, light clay, soil, sand and gravel in layers. In mountains of this kind there are numerous caves, hollows, torrent beds (*wādīs*), springs, and streams, and they abound as in Palestine and Ṭabaristān in vegetation of all kinds. In the caves and hollows of the mountains, water gathers, remaining imprisoned when there is no outlet, and, if the earth near it is hot, becoming heated in contact with it and so turning into steam. In seeking an outlet for expansion, the steam may burst open the earth, which quakes and in places subsides. If no outlet is found, the earthquakes continue until the interior of the caves and hollows is cooled and the steam is condensed. The resultant liquid remains in these places for long periods of time, in the course of which its purity and density are increased and it ends by becoming (unstable) quicksilver.[2] In a later passage this "mineral" is described as the product of moisture compounded at high temperature with earth-like atoms. It forms with sulphur (itself described as the product of moisture compounded at high temperature with oil-like atoms) the basis of the other metals, the character of which depends upon the precise conditions of heat and cold to which the compound has been subjected and upon the proportions of the two constituents. Gold, silver, copper, lead, iron and antimony are thus formed and the

[1] *Rasā'il*, II, 81 f. The Brethren here insert a passage giving their theory of the rise of human civilization. They declare that as the mountains are built up in the ocean depths, the seas rise and overflow plains and steppes until in the course of time the plains become seas and the seas dry land. Upon the land raised out of the sea, rain falls, and streams are formed which bring down soil and sand. In this, plants, herbage of various kinds and trees grow. They become the lurking-place of wild animals and attract the attention of man, who comes in search of timber and game. He remains to cultivate the land so that it bears crops of various kinds. Then villages and towns grow up and men make their homes there.

[2] *Rasā'il*, II, 83–5.

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jewels (literally "the stone-like minerals") similarly, fire being the decisive factor for them.[1]

Gold is the mineral substance possessing the most perfectly balanced composition and the purest constituents, whose spirit is one with its soul and its soul one with its body—by the spirit being meant the air atoms, by the soul the water atoms and by the body the earth atoms. Fire is the determining element in minerals, and gold is the noblest of the metals, as jacynth amongst the jewels, because fire cannot resolve it into its constituent parts. In the place of its origin, gold was subjected to a constant and equable heat for a long period of time, and that too was a factor in its perfection.[2] Next to it is silver, which might have become the more precious metal if there had not occurred a sudden cooling in the mine.[3] A similar theory is propounded for the formation of the other "minerals" of all classes.[4]

The minerals form the lowest stage in an ascending series which culminates in man and the angels. Above the stage of the minerals is that of the vegetables, the connecting link being a compound of mineral and vegetable, and above the vegetable stage is that of the animals, whose noblest member is man.[5] In the treatise on the vegetable kingdom, the various plants are attributed to special regions of the earth, each with its own character. The minerals are similarly attributed. Thus, gold is formed only in sandy deserts and mountains and amongst soft rocks; silver, copper, iron and the like only in the heart of mountains and of rocks compounded with soft soil; sulphur only in moist earth and soft soils; oily liquids, copperas (green vitriol) and gum benzoin[6] (*aklāḥ*) in marshes and water-logged places; gypsum and ceruse in sandy soils which are mixed with gravel, and the alums and vitriols only in sour and barren soils.

There are innumerable kinds of minerals, some of them unknown to man; but experts recognize about nine hundred varieties, differing in their nature, colour, taste, smell, and mass, and

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[1] *Rasā'il* II, 91 ff. [2] *Ibid.* II, 99. [3] *Ibid.* II, 101.

[4] *Ibid.* II, 100 ff. The theory has its place in the history and practice of alchemy. See below, p. 500.

[5] All the three kingdoms are compounds of the four elements acted upon by "Nature", which is the power of the Universal Spirit working through the agency of the skies and the stars. (*Rasā'il*, II, 112 f., 128.)

[6] The identification is not certain.

in their good and harmful qualities. Some are stone-like and hard, but are fusible with fire and harden when cold. Such are gold, silver, copper, iron, lead, glass and the like. Others of the kind are not fusible except by the most extreme heat and are not to be fractured except by use of a diamond. Such are the jacynth and the cornelian. Another variety is earth-like and not fusible but friable (e.g. the salts, the vitriols and talc), and another is fluid, moist and averse to fire (e.g. quicksilver), while still another is aetherial, oil-like and consumable by fire (e.g. sulphur and the arsenics).

There is further a vegetable class, comprising such minerals as coral, both white and red, and there is also an animal class, which includes the pearls. Certain substances produced by congelation form a further class in which are to be found such substances as ambergris and the bezoars. The former is by origin dew which falls upon the surface of the sea and in certain places and at particular times becomes congealed. The bezoars also are congealed dew which has fallen on particular kinds of rocks and become solidified in their interstices. And pearls too have the same origin, for they are formed from drops of dew caught by oysters, sea creatures within which the dew congeals and hardens.

After a restatement of their theories concerning the world of matter and the influence of the astral upon the terrestrial, the Brethren turn to the vegetable kingdom. In introducing their treatise on this subject the Brethren declare their object to be an exposition of the genera of plants; of their origins and growth; of the causes of their differentiation in form, colour, taste, smell, and the shape of their leaves, flowers, berries (grains) and seeds; of their growth (i.e. habit); of their roots and branches and of the principles of their beneficial qualities.[1]

Every kind of plant has a germ ("origin") which is a chyme (*kaymūs*) or mixture of a particular kind. From a given mixture (of elements) a particular chyme is produced, and from it there should grow only one particular kind of plant. Now if the original

[1] "Although plants are obvious and visible creations, the cause of their existence is hidden and veiled from the perception of man. It is what the philosophers call 'the natural forces', what the *sharī'a* calls the 'angels and troops of Allah appointed for the nurture of plants and the generation of animals and the composition of minerals' and what we call the 'partial spirits'." (*Rasā'il*, II, 130.)

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matter were always irrigated by the same water, planted in the same kind of soil, fanned by the same breeze and ripened by the same uniform heat from the sun, it would be capable of receiving any form. But there are secondary kinds of matter with it, capable from the nature of their origin of producing only particular forms. Thus, although earth and water are the materials from which the plants both of wheat and cotton grow, yet from the cotton plant there comes nothing but fibre (whence are produced cloth and garments), and from the wheat plant nothing but flour (whence are produced dough and bread). This comes about by the fact that when moisture and the subtile parts of the soil reach the roots of plants, they are changed and become chymes of a particular composition, from which a special plant is produced. The same rule holds for the varieties of leaf, blossom, root and grain.[1]

The genera of the plants are formed under the influence of the various powers[2] of the universal celestial spirit, the partial spirit which is particularly concerned with plants being known as the "vegetable spirit". To this Allah has assigned seven powers; namely, the attractive, the retentive, the digestive, the propulsive, the nutritive, the expansive and the formative. Their functions are respectively to draw the distilled essences of the four elements, in a form suited to the requirements of each genus, to the roots of each plant, to retain them there, to digest them, to propel them to the different parts of the plant, to bring about their assimilation, to encourage growth and to form the variety of shapes and colours.

The first of the plant genera comprises the trees. Amongst them are included all plants possessing an erect stem. There are perfect and imperfect forms of them. The perfect form is that which possesses root-fibres, main root, shoots, branches, leaves, blossoms, fruit, bark and resin: the imperfect form is that which lacks one or more of these parts. The second of the plant genera includes the stemless plants; for example, those which trail along the ground or which cling to trees and are raised into the air. Such are the grape-vine, the gourd and the melon.

A different classification of the plants ranges them according to their habitat, i.e. according as they are to be found in deserts and wildernesses, on mountain-tops, on river-banks, sea-shores, or in

[1] *Rasa'il*, II, 132.
[2] "The prophet calls them 'angels'." (*Ibid.* II, 134.)

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pools and hollows. To a special class belong those which are sown and cultivated by men, in towns or arable lands and gardens.

The majority of plants grow on the surface of the soil; some, like the sugar-cane and rice, will grow only under water, others on the surface of water and still others on rocks.[1]

Of the various grades of plants the humblest are the insignificant growths to be found on the rubbish heaps of encampments, and the noblest are those, the palms, which come nearest in their qualities to the animal kingdom. The former spring up in the cool moisture of a night and are withered by the noonday sun, while the palms stand far higher in the natural scale. Individuals of them are either of the male or the female sex, in the former being the active power and in the latter the passive; in other plants the powers do not lie in distinct individuals. Since these phenomena are elsewhere to be found only amongst animals, the palm is animal in spirit but vegetable in body.[2]

Plants, like the lowest of the animals,[3] have only a single sense, that of touch. This is proved by the fact that they send out roots towards moist places and refrain from any approach to rocks and dry places. Further, plants which have been set in a restricted place turn aside in the endeavour to find more room, and plants which have been covered with a roof will find a way through any hole within their reach. These are facts which show that plants have a sense of touch and sufficient discrimination for their needs.[4] Their creation preceded in time that of the animals, for they provided the substance of animal nourishment, being able by their construction to absorb the elements in a form suitable for animal consumption. But for them, animals would have had to obtain their food directly from the soil[5]

The characteristic which distinguishes the animals from the plants is stated by the Brethren to be the capacity to change position in the search for food, and man differs from the other

[1] *Rasā'il*, II, 136 f. [2] *Ibid.* II, 142 f.

[3] This is declared to be the *ḥalazūn*, a small slug which inhabits certain reeds growing on river-banks and sea-shores. When in search of food this creature puts out a part of its body and expands when it touches moisture, but contracts when it meets a dry patch.

[4] *Ibid.* II, 143 f. The Brethren declare that it would not be in accord with Divine wisdom to inflict pain upon plants without having endowed them with the power to escape it or with the means of warding off danger.

[5] *Ibid.* II, 154.

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animals in possessing the faculties of speech and reason. All created things are alike in having been created from the four elements (the *arkān*); plants are superior to minerals in being able to absorb nourishment, to grow and feel; animals in addition to these powers have one or more of the five senses, and man, while of the animal kingdom in other respects and possessing all the senses, also speaks and reasons.[1]

The animals are divided into those which are perfect and those which are imperfect in their creation. In the perfect class are included those which have sexual congress, conceive, bear and suckle their young; in the imperfect class are those which originate in putrescences. Between the two classes is that of the creatures which lay and incubate eggs and feed their young. The animals of imperfect creation precede the perfect ones in origin; also they are brought into being in a shorter space of time. Further, the marine animals precede the land animals in order of creation, seeing that the water preceded the earth in origin. The perfect animals originated in the clay, being produced by male and female in the earth beneath the equator, where day and night are equal, the climate always uniform (between hot and cold) and the matter susceptible of receiving form is always to be found. It was there that Adam was brought into being. In the order of creation the animals preceded man, for whom and because of whom they exist.

Of the grades of animals, the lowest is that which has only one sense. The next grade is that of the grubs, which originate and crawl about on the leaves, blossom and fruit of trees and plants. They have two senses, namely those of taste and touch. The third grade, which includes the marine and aquatic animals and those which inhabit dark places, has three senses, adding the sense of smell to the two mentioned. The fourth grade, which includes the insects and creeping things which crawl about in dark places, has all the senses but that of sight, which is unnecessary to it. The most perfect grade is that which possesses all the senses, and it is the grade of the animals of perfect creation.

Another classification of the animals is according to their habitat. There are those which live in the water, namely creatures such as fishes, crabs, frogs, oysters and the like; those which inhabit the air, namely the majority of birds and the swarming

[1] *Rasā'il*, II, 153.

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insects; those which dwell on land, namely domestic cattle and wild beasts; and those which dwell in the soil, namely the worms. Of all these animals some are consumers and the rest the consumed.[1]

The animals most perfect in form are those which have the most complete structure. Their external features are a number of limbs and members, each composed of bones put together at symmetrically constructed joints and held together by nerves and ligatures, the interstices being filled with flesh interwoven with veins and the whole protected by skin covered with hair, fur, wool, feathers, shell or scales. Within the body are contained the vital organs, namely, the brain, lungs, heart, liver, spleen, kidneys, bladder, intestines, stomach, crop, gizzard and the rest.[2]

There is no member of the body which does not serve some other, either by protecting or supplementing it or by enabling it to function. An example of this is the brain, which dominates the human body as sovereign. It is the place of origin of the senses, the source of thought, the abode of consideration, the treasure-house of memory, the dwelling-place of the soul and the seat of the reason, and it is served by the heart and the other parts of the body. The function of the heart is to be the controller and regulator of the body: it is the starting-point of the pulsating veins (the arteries) and the source of the body's natural heat. The heart in its turn is served by three members; the liver, the pulsating veins and the lungs, and the liver is assisted in its functions by five other members. The chief of them is the lungs, "the house of breath", which are themselves served by the chest, diaphragm, windpipe and nostrils. Here the Brethren find a suitable place for a description of the function of breathing. In this, they say, the air sucked in through the nostrils enters the windpipe, where its temperature is made normal, and thence reaches the lungs, in which it is purified. It then enters the heart, where it cools the natural heat (of the body), and from there issues into the pulsating veins and so reaches all those parts of the body known as *nabḍ* ("pulse").[3] From the heart also the burnt-up air emerges into the lungs and

[1] *Rasā'il*, II, 167 f. [2] *Ibid.* II, 159 f.

[3] This was the commonly accepted theory in the western world until Harvey's discoveries concerning the circulation of the blood.

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so by way of the windpipe into the nostrils or the mouth. The chest serves the lungs by expanding when air is sucked in and contracting when the air is exhaled.[1]

Similar illustrations are provided for the organs concerned in the digestive processes.[2]

In the course of their treatise, the Brethren point out how various animals are provided with special organs suited to their habits of life. Thus the herbivorous land animals have been granted wide mouths to enable them to seize their food, sharp incisor teeth for cutting it and hard molars for grinding the hard parts of herbage, grain, leaves, bark and kernels; also they have a wide smooth gullet, through which the masticated food is swallowed down, and a capacious stomach in which it is contained. Some animals bring back what they have swallowed, in order to masticate it a second time. The product of the second mastication is received after it is swallowed in a second stomach distinct from the first. It is so constructed that it may separate the coarser parts of the food, which are sent to the bowels, from the more subtile, which are sent to the liver, and that it may mature (cook) and purify a second time. What remains passes to vessels adapted to receive it. These are the spleen, the gall-bladder, the heart, the kidneys and the hollow veins, the latter acting as the channels and ducts through which the purified blood passes to all parts of the body. In the body of the male, for the surplus of the nutrient materials, there are divinely provided certain organs, vessels and channels into which it passes. It forms the semen, which, at the time of mating, flows from these organs into the womb of the female, through certain channels and organs in her body which have been prepared to receive it and be the seed-bed in which the young originate and grow.

The wild beasts which eat flesh are by nature and in the structure of some of their organs different from the herbivorous animals. Seeing that they derive their nutriment by eating the bodies of other animals, they have been provided by the Creator with hard incisor teeth, strong curved claws and powerful forearms (*zanadāt*), and further they have a lightness of spring and the power to leap far in order to pounce upon and rend their prey.

'The Creator in His wisdom in providing animals with perfection

[1] *Rasā'il*, II, 161–3. [2] *Ibid.* II, 163.

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of form, distinguished the two halves, the right and the left, whereby they correspond to the first real number ("one" being merely a unit and not a "number") and the combinations of the elements. The body's three divisions, namely, two sides and middle, make it correspond with the first odd number, and its four humours with the first square number. The five senses accord with the first "round" number and the five "qualities", of which four are the "natural" (sublunar) qualities and the fifth the "celestial" quality. In its power to move in six directions (towards the four points of the compass and upwards and downwards) it possesses something which corresponds to the first "complete" number and the number of the faces of a cube. The seven physical faculties correspond to the first "perfect" number and the number of the planets, while the eight possible mixtures (of the elements) correspond to the first cubed number. The structure of the body is in nine layers corresponding to the number of the spheres which surround the earth, and there are in the body twelve openings which are as doorways to the perceptions and correspond to the twelve signs of the zodiac. The twenty-eight vertebrae, upon which depends the erect carriage of the body, correspond to the number of the stations of the moon, and the three hundred and sixty veins of the body are the same in number as the degrees of the zodiac and the days of the year. Thus, he that counts and considers the parts of the body in general will find that they all correspond in number with particular existing phenomena. "This establishes the declaration of the Pythagoreans that all existing things are grouped according to the nature of number."[1]

To complete the picture of science as presented by the Brethren it is necessary to state that they included magic, astrology, and divination within its scope, and in their study of these arts used Indian and Persian as well as Greek authorities.[2] They were careful, however, to proclaim that these arts were only for the initiated,[3] and that parts were true and parts false.[4]

Two works almost contemporary with those of the Ikhwān provide a concise conspectus of science as known to Islam in

[1] *Rasā'il*, II, 168 f.
[2] *Ibid.* IV, 320 ff.
[3] *Ibid.* IV, 340.
[4] *Ibid.* IV, 347.

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the fourth and most fruitful century of its history, and serve in some measure to supplement what, in spite of the wide scope of their work, the Ikhwān have not adequately covered. These are the *Mafātīḥ al-'ulūm* ("The Keys of the Sciences") composed in 976 by Muhammad ibn Aḥmad ibn Yūsuf "the Scribe" of Khwārazm, and the *Fihrist* ("Index"), composed in 988 by Ibn al-Nadīm al-Warrāq, the "Paperseller" or "Copyist", of Baghdad.[1]

The *Mafātīḥ al-'ulūm* deals chiefly with the terms employed in the two branches of science, namely the "Arab" and the "foreign", and defines these terms with some attention to the detail of what they represent. The first discourse on the "Arab" sciences has six chapters dealing respectively with *fiqh*, *kalām*, grammar, secretaryship, poetry and prosody and history. Each chapter makes extensive digressions, so that that concerned with *fiqh*, for example, in dealing with the *zakāt* (the alms-tax), gives the names used technically for large and small cattle at various stages of their existence, and the chapter on *kalām* enumerates the various Islamic sects and, moreover, the various Christian, Jewish and "heretical" sects with which the author was familiar. The second discourse deals with philosophy, and includes theology (in the Aristotelian sense), philosophic terminology, logic, medicine, arithmetic, geometry, astronomy (with judicial astrology), music, mechanics and alchemy.

It is in the second part that this work most supplements the treatise of the Ikhwān. The chapter on medicine has sections dealing with anatomy (in which the names, positions and functions of different parts of the body are set out), with diseases and sicknesses, foods, medicaments, both simple and compound, physicians' weights and measures, and, finally, with a number of technical terms. The chapter on arithmetic is of some importance for the history of the subject, because it explains, as though it were dealing with an unfamiliar topic, the functions of the "Indian" numerals[2] and that of the "cipher" in particular. It is described

[1] E. G. Browne, *Literary History of Persia*, 1, 382 ff.

[2] Our "Arabic" numerals. (Carra de Vaux sees in the Arabic adjective *Hindī* a corruption of *Handisī*, i.e. "geometric".) Researches into the calculations made to determine legal shares in inheritance (*'ilm al-farā'iḍ*), into the origins of the algebraic terms *māl* (square) and *shay'* (square root, the familiar x of the text-books) and into the terminology of quadratic equations make it probable

as a small circle whose use is to preserve the order of the columns, so that it may be known that a numeral which is not in the first column will belong to the "tens" if followed by a single cipher, to the "hundreds" if followed by two ciphers, and so forth to any degree desired. In the chapter on alchemy the apparatus, processes and the substances used in "The Art" are described.

The *Fihrist* may be said in general terms to deal with the same topics as the *Mafātīḥ al-'ulūm*, but it is historical and bibliographical rather than descriptive. Its main interest in the present context is for the ideas prevalent concerning the introduction of "foreign" learning into Islam, and for the life and work of the most outstanding figures both Muslim and non-Muslim, in the realm of science.

Except in the fields of astronomy and medicine, where practical observations were added to (although they did not modify) Greek theories, there is little trace of advance made by Muslim science in the centuries after the fourth. Even in astronomy, Ibn Khaldūn (eighth century) declared that scientific observation of the stars had been very little practised after the death of the Caliph Ma'mūn, and that for practical purposes the observations of the ancients were commonly relied upon.[1] Ibn Khaldūn, however, was not in possession of all the facts, and even if no greater practical use was made of astronomy in his day[2] than it is at the present, and if the authority of the past masters was so great that no new theories were evolved,[3] yet for centuries study of the heavens was continuous, new observatories were built and new forms of the old

that all these too were derived from Indian sources. (See J. Ruska, *Zur ältesten arabischen Algebra und Rechenkunst* (on the Algebra of Muḥammad ibn Mūsā al-Khwārazmī), Sitzungsber. d. Heidelberger Akad. d. Wissenschaften (Phil.-Hist. Klasse) 1917, 2te Abhandlung).

[1] *Prolégomènes*, ed. Quatremère, III, 105 f.

[2] For determining, for example, the beginning and end of Ramaḍān. To this day it is not astronomical calculation which determines the date but actual observation of the new moon's rising.

[3] Speculation continued even if it resulted in no new theory. Yāqūt in the *Mu'jam al-buldān* (begun in Muḥarram, 625 = December 1227) reports how the ancients disputed about the shape of the earth, some declaring it was a plane, others that it was drum-shaped, others that it had the shape of a dome set up on its rim, others that it was cylindrical. As for the revolution of the stars, some said that it was due to the rotation of the earth itself and not to the revolution of the heavens. (*Mu'jam al-buldān*, ed. F. Wuestenfeld, I, 14.)

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astronomical instruments were constructed. By this activity the foundations of modern astronomy were laid, a fact which is made obvious by the Arabic nomenclature still in use.

The regard for authority is more obvious in medicine where "the mighty name" of Galen has kept some Muslim practitioners of that art in subjection to this very day. Even the greatest of them, Rhazes and Avicenna, were content to follow the Greeks for their anatomy, physiology and pathology, although occasionally an accident enabled first-hand observation to correct theory. A widely quoted instance of this is to be found in the diary of the physician 'Abd al-Laṭīf al-Baghdādī (d. 629/1231), who, during his travels in Egypt discovered a great collection of skeletons, accumulated during a pestilence, on the hills at Maks, and was there able by the evidence of his own eyes to correct Galen's description of the structure of the human mandible.[1] It had never occurred to him (he flourished during the latter half of the sixth and the beginning of the seventh century of Islam) previously to examine a subject for himself in order to discover the truth, nor had there been any dissection of the human body by even the most eminent of his predecessors, or by any amongst his fellow-practitioners. This was not in any measure due to prohibitions of the Islamic authorities, but rather to age-old prejudice against interference with the dead. Islam itself had no scruples about mutilation of the human body, when alive at any rate, for mutilation was the punishment recognized by the *shar'* for theft. The importance of "Arab" medicine lies in the evidence of original experiment in treatment and exact empirical observation of the aetiology and symptoms of disease. As Professor Browne remarks in his *Arabian Medicine*,[2] the clinical notes of these old "Arabian" physicians are of much greater interest and importance than their obsolete physiology and pathology or their second-hand anatomy."[3] Their success as physicians probably lay in their

[1] *Kitāb al-Ifādah*, ed. J. White (Oxford, 1788), pp. 272 ff.; tr. S. de Sacy (*Relation de l'Égypte*, Paris, 1810), p. 418. [2] Cambridge, 1921, p. 50.

[3] There are evidences even in the *Arabian Nights* of the study of disease symptoms as reported in the examination of the learned slave-girl Tawaddud. Her reply to a question on diagnosis is that the physician may diagnose by palpation hardness, heat, dryness, cold and moisture. By ocular perception he notes the tokens of internal affections; yellowness of the eyes indicating jaundice, twisting of the back, pleurisy, and so forth. Symptoms of internal complaints may be diagnosed from six sources, namely, from the patient's reactions, from

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ignoring theories and their employment of means suggested by experience and common sense.

One further branch of "science", namely, alchemy, occupied a considerable place in the attentions of the Muslim *savants*, although its claim to be regarded as a serious branch of knowledge was often in dispute. The subject was of foreign derivation, having been introduced into Islam from Egypt or Greece, but, like other new subjects of promise, it was taken up with avidity. At no time in its history can it be said to have had fixed and universally accepted principles such as appear in medicine. The philosophic basis of the art rested on the Aristotelian theory that all things ultimately were composed of the four "matrices", namely, fire, air, water and earth. It has been seen that according to the Ikhwān al-Ṣafā mercury and sulphur were the more immediate bases of the minerals, and the belief of the alchemist was that elixirs might be discovered which would transmute less noble minerals or metals, such as lead, tin, copper, mercury or even iron, into the precious metals such as gold and silver. But the method followed by the individual investigator depended upon his answer to the question whether the metals differed from each other in their essence or only in their accidental qualities.

Abu Naṣr al-Fārābī held that all metals belong to the same species and that it is therefore possible to convert one metal into another. Another authority, Al-Ṭughrā'ī, held that they differed only in accidentals and nevertheless that the secret of transmutation lay not in creating or discovering the substance through which the more precious metal differed from the less precious one, but in careful preparation of the elemental materials which would display the appropriate differences once the desired combination was successfully achieved.

Both the theory and the practice were denounced as false and dishonest by men of authority in Islam, although alchemy continued to flourish in spite of them until the rise of modern chemistry. Avicenna held that metals were distinguished from one another by specific differences and that each formed a species by itself and distinct from the rest.[1] His view therefore was that it

bodily evacuation, from pain, from the locality, from swellings and external symptoms. (*Alf layla wa-layla*, ed. Macnaghten (Calcutta, 1831–42), II, 514 f.)

[1] Cf. Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, III, 200 f., 229, 233 f.

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was impossible to change one metal into another and that the practitioners of the "Art" merely produced colourable imitations of the precious metals, the essential character of the base ones being retained in them.[1] According to Mas'ūdī[2] alchemy bred deceit and trickery, and it was denounced by the philosopher al-Kindī in a treatise which proved man's incapacity to rival Nature in its workings. Ibn Khaldūn held similar views and refused even to recognize that alchemy was a branch of "natural science". Its pretensions he declared to be false and asserted that if it were possible to change one thing into another essentially different then the art belonged to the realm of magic, since it meant the creation of something out of materials not appropriate to it.[3]

It will have been made apparent that the debt which science in Islam owed to the Greek philosophers, and in a lesser degree to the Indians and Persians, for its general theories, was a great one. The Muslim *savants* accepted the theories as they stood, and on the whole left the field of the physical science much as they had found it. Yet, during the period when their activities were encouraged, they enriched the subjects in which they engaged by the accumulation of numerous observed facts and by their vigorous pursuit of knowledge for practical ends. After the fifth century of Islam, as has been indicated, it is evident that the spirit of inquiry was dulled, for the outstanding figures in the scientific world were no longer Muslims although working under Muslim protection and encouragement. In large measure this would appear to be due to the growing influence of the *'ulamā* and the hardening of dogmatic feeling in the various "schools" of the faith. Rigid orthodoxy disapproved of philosophers (even of those "natural" philosophers whose researches into the works of Creation led them to acknowledge the omnipotence of the Creator), the reason being that they declared man to be no different from other creatures, that his soul perished like his body and that there was

[1] *Avicennae de Congelatione et Conglutinatione Lapidum* (an extract from the *Kitāb al-Shifā*), (ed. E. J. Holmyard, Paris, 1927), p. 95. He nevertheless recognized alchemy as a branch of "natural science" and says its object is to deprive the "mineral essences" (i.e. the metals) of their particular character and to give them other characters, so that it may lead ultimately to the derivation of gold and silver from other bodies. (*Risālah Taqsīm al-'ulūm*, B.M. MS. Add. 16,659, fol. 349 a.)

[2] *Murūj al-dhahab*, VIII, 175-7.

[3] *Prolégomènes*, ed. Quatremère, III, 208.

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no resurrection in the hereafter.[1] For that reason orthodoxy branded them as heretics and was careful to declare whether any Muslim who devoted himself to philosophy could be regarded as a true believer or not,[2] and it was on that account also that the scientific side of *'ilm* was always kept distinct from the religious, with no attempt made to harmonize the two.

Ghazālī,[3] in his exposition of the duties of the true believer, discusses the question of how far it was necessary for him to inquire for himself into the facts of religion and natural phenomena. At the outset the author quotes two *ḥadīths*, of which one makes it the bounden duty of every Muslim to seek "knowledge", while the other is the widely-quoted counsel of perfection which bids man "seek knowledge, even if it be in China". The difficulty lies in the definition of *'ilm*: the scholastic theologians say it is their *kalām*, the *faqīhs* that it is *fiqh*, and the Ṣūfīs that it is Ṣūfīsm, while Abu Ṭālib al-Makkī[4] maintained that it was the learning which concerned itself with the five fundamental requirements of Islam.

Without saying more to determine the question than that only such knowledge is requisite as will enable the believer to perform the essential duties imposed on him by his faith, Ghazālī proceeds to a classification of the various aspects of knowledge. Knowledge, he says, is divided into that which is connected with the *shar'* and that which is unconnected therewith. In the first class is comprised all the science which is derived from the Prophets and is not acquired by reasoning, like arithmetic, or by experience, like medicine, or by the hearing, like language. In the second class is contained all the rest and it is divided into three parts, the recommended, the deprecated, and the permitted (indifferent). The first part comprises those branches of knowledge which concern the

[1] Cf. al-Qifti, *Ta'rīkh al-ḥukamā*, p. 50. For the attitude of Ghazāli on the question in his *Tahāfut al-falāsifa* and other works, see below, pp. 503 ff.

[2] Cf. the case of 'Abd al-Salām, who studied the "Sciences of the Ancients", was accused of heresy and had his books publicly burned (Qifti, *ibid.* pp. 228 f.), and the case also of 'Umar Khayyām, who "taught the science of the Greeks" and the inward meanings of whose works were "serpents stinging the *sharī'a*" (*ibid.* p. 244), while Rhazes, "the physician of the Muslims" (*ibid.*, p. 271), and al-Fārābi, "the philosopher of the Muslims" (*ibid.*, p. 277), are carefully described as "unobjectionable" (*ghayru mudāfa'*). The latter is described as having distinguished between divine inspiration (*waḥy*) and philosophy.

[3] *Ihya*, I, 12 ff.

[4] Died 996. Best known for his treatise on Ṣūfism, the *Qūt al-qulūb*.

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welfare of the world, such as medicine and mathematics; and each science of this kind must be practised by at least one member of the community (i.e. it is *farḍ al-kifāya*), the rest of whom are exempt. In the same class as these sciences are certain fundamental crafts such as husbandry, weaving, the tending of beasts and certain arts such as cupping and tailoring. But deep research into the minutiae of mathematics and the laws of medicine is unnecessary and superfluous, as being of no immediate practical value. The blameworthy sciences are those concerned with magic, talismans and jugglery, for the reason that they rely for their validity upon reference to powers other than Allah.[1] The permitted arts (i.e. those towards the practice of which the law is indifferent) are such studies as poetry and history.[2]

In his autobiographical work entitled *Al-Munqidh min al-ḍalāl*[3] ("The Deliverer from Error"), Ghazālī indicates that fanatical adherents of Islam believed they were helping the faith by declaring false all knowledge derived from the philosophers, so that they went to the extent of denying what was said about the eclipses of the sun and moon. He protests that the function of the "natural" sciences is to deal with the celestial "spheres" and the stars, with the elements which exist below the "sphere" of the moon (namely water, air, earth, fire), with their compounds (which are animals, plants and minerals) and with the causes of their changing and combining. Religion therefore does not demand that this science should be denounced any more than that medicine should be denounced, except in particular questions which are specified in the book called *Tahāfut al-falāsifa*, "The Confusion of the Philosophers", for the root purpose of all these sciences is to make it known that "Nature" is subordinated to Allah, and does not act alone but is directed by its Creator. As for the conceptions of the ancients which have been transmitted by the philosophers, some, he says, may arise spontaneously in any mind, others may be found in works which are concerned with the *shar'*, and the principles of most are to be found in the books of the Ṣūfīs. Even if they are not so to be found, provided that the subject-matter is in itself in conformity with reason, susceptible of proof by argument and not contrary to the Book and the *sunna*, then

[1] Thus Ibn Khaldūn, *Prolégomènes*, ed. Quatremère, III, 136.
[2] Ghazālī, *Ihya*, I, 14. [3] Ed. Cairo, A.H. 1309, pp. 9 ff.

there is no need to denounce and forbid it. Otherwise if all ancient truths had to be rejected, then the Koran itself and the Traditions of the Prophet and authentic historical material would have to be rejected merely because the Ikhwān al-Ṣafā had cited them. On the other hand those who, like the Ikhwān al-Ṣafā, make a study of philosophy are apt also to fall into error, for they mingle what they approve of philosophy with prophetic wisdom and Ṣūfī lore and then hasten to accept the falsehood mingled with the truth. The reading of their books should for this reason be discouraged.

It was only in the unlearned that Ghazālī discouraged inquiry. He himself was fully acquainted with the scientific thought of his day and much of it he accepted as true. In the *Tahāfut* there is a clear exposition of the various branches of "Natural Science", in the course of which the author explains what he would retain and what reject. He proclaims that certain of the beliefs of some of the philosophers (al-Fārābī and Ibn Sīnā being singled out for special mention) do not offend the principles of Islam and there is no necessity for the confirmation of these beliefs by prophets and apostles. An example of such beliefs is that the eclipse of the moon is due to the fact that its light is blotted out by the intervention of the earth between it and the sun, from which the moon receives its light. These and similar beliefs may be left without question because they can be mathematically proved.[1]

In recounting what he regards as acceptable, Ghazālī provides a conspectus of the subjects of scientific study in his day, which show little change from those of the Ikhwān. They include the general principles of Aristotelian physics (the ideas of motion, change etc.), the composition of the heavens and the four elements and their "natural qualities", "Generation and Corruption", the conditions of the elements which produce the meteorological phenomena such as clouds, rain, thunder and the rest, the "mineral essences", the laws of plants, zoology, "the animal spirit and the perceptive powers and the fact that the human soul does not die with the death of the body and that it [the soul] is a spiritual essence".

The foregoing are regarded as the principal subjects. Derivative

[1] *Algazel Tahafot al-Falasifat*, ed. M. Bouyges, S.J. (Beyrouth, 1927), pp. 10 f.

from them are a number of subjects which form the "departmental" sciences, of which the first is medicine. Its object is defined as the knowledge of the beginnings of the human body, its condition in health and sickness, the causes and symptoms of the latter and the means of warding it off and preserving good health. The second derivative subject is judicial astrology, which has for its aim the prognostication of terrestrial events from the positions and combinations of the stars. The third subject is physiognomy, which concerns itself with the diagnosis of character from physical qualities; the fourth is the interpretation of dreams; the fifth is that of talismans ("the connection of celestial influences with certain terrestrial objects so as to produce a force which shall work in unfamiliar fashion in the terrestrial part of the universe") and the sixth that of "white magic", which is "the mingling of the earthly essences in such fashion as to produce unfamiliar things". The seventh and last of the derivative sciences is that of alchemy, the purpose of which is to "change the character of the 'mineral essences' and so achieve the production of gold and silver by a species of devices".[1]

To these "natural sciences" Ghazālī takes no exception, and it is on more general and metaphysical questions that he joins issue with the philosophers. This is not the place in which to discuss them but they are summarized in the *Tahāfut* under four headings: (1) The decision of the philosophers that the association which is apparent in the world of phenomena between causes and effects is a necessary one and that it is not within the bounds of possibility to find the cause without the effect nor the effect without the cause; (2) the assertion of the philosophers that the human soul has an independent existence; (3) the statement of the philosophers that the destruction of the human soul is impossible; and (4) that the human soul cannot return to the body (after death).[2]

Orthodox Islam has not moved from the position assumed by Ghazālī in the fifth century of its history, but individual Muslims have at various times adopted the results of the scientific investigations of their day rather than those of scholastic theology, and by their work made their place in the history of science one of recognized importance.

[1] This seems to bear evidence of Avicenna's definition. See above, p. 501.
[2] *Algazel Tahafot*, pp. 268 ff.

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"b." indicates *ibn.*

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BY

REUBEN LEVY

Professor of Persian in the University of Cambridge

HISTORICAL RESEARCH INSTITUTE,

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