Scientific American.

A STUDY OF THE NAVIES OF ANTIQUITY.

When we study the history of the first Punic war, and endeavor to get an idea of the maritime operations that had so great an influence upon the result of the contest, we are struck by the want of accordance that is revealed upon every page between the elements of the drama whose phases we are following. The ports contain no fleets; the days are not long enough for the maneuvers described; the effective material is out of all proportion to the population of the two republics; and the power of production of the dockyards that had scarcely been created exceeds that of all the arsenals of Europe combined.

Historical criticism is powerless to explain such contradictions or to rectify such errors. A single version exists, which is repeated by old writers with few variations, and which has been accepted by modern writers with a unanimity that proves an identity of origin much more than a faithfulness of the narratives.

Technical criticism puts us into a dilemma. Either we must believe that the Romans were supernatural beings—a fact that would add nothing to their glory—or else Polybius has not wished to deny those too flattering traditions of a people whose involuntary guest he was, and whom he passionately admired.

If, after establishing the error, we seek the cause of it, if we accept all that is plausible and throw out only the contradictory facts, if we reduce to a minimum the doubt that it is necessary to undergo and the negatives to which we are inevitably led, we find that the entire difficulty is summed up in a single question, and one that belongs to the domain of naval archæology.

Is it or is it not true that the quinqueremes constructed by the Romans when they undertook to create a navy, were ships that carried a crew of from 400 to 500 men, that displaced 500 tons, and that were analogous to those Greek penteconters which we have seen figuring at the battle of Chio? As regards this, Polybius is explicit, and it is necessary either to discuss his competence or to believe with Enneus Florus in the intervention of the gods.

When we undertake to restore the galleys that were victorious at Myle and Ecnomos, we find no positive documents that permit of bringing the Athenian trireme to life again, and at the same time the types that preceded and followed it. We know that the first Roman galleys were imitations of those of the Carthaginians, a nation of merchants, who lorded it over the entire west basin of the Mediterranean; we know that they were constructed and armed in immense numbers, in a very short time, by a people who possessed no dockyards, no tools, and no supplies; we know about their navigation and their prowess; and we can still study the configuration of the shores where the fleets were hauled up on land without preparations.

This is enough, in proceeding by exclusion, to establish the general characters of the vessels which figured in the first Punic war. In uniting such characters by an estimate and a sketch, we get the boat shown in Fig. 1—a decked bark 65 feet in length, of 45 tons displacement, and having a normal crew of 70 men. Its propelling apparatus consists of five large oars on each side. It is a construction which recalls at one and the same time the Spanish balancelle, the Ligurian tartan, and that heraldic galley which painters and sculptors have undoubtedly borrowed from some tradition of remote times. Without desiring to enter into details that would be out of place, without pretending to an accuracy that the subject does not admit of, I shall compare this quinquereme with the penteconter of 300 rowers described by Polybius, and I shall set them opposite each other in a narrative given by that author himself. It is one of the clearest and most interesting of his history.

The Battle of Drepana.—The Romans had been laying siege to Lilybæum (Marsala) for more than a year. Drepana (Trapani) and Lilybæum were the only ports that remained to the Carthaginians in Sicily. They held possession of the last named city because nature had endowed it with an excellent port, easy to defend, and very well arranged for the use of the galleys. Hannibal, the son of Hamilcar, had been sent to succor the place, and many deadly fights had taken place between the two armies. The besieged had several times vainly attempted to destroy the engines of the besiegers, when one day there arose a violent tempest that favored their designs. They made a sortie, and, after a bloody combat, in which the Roman army met with great losses, the works were overturned and the engines burned, so that the walls of Lilybæum could be rebuilt.

Fig. 3.—ORDER OF BATTLE OF THE ROMAN AND CARTHAGINIAN FLEETS. (A. Carthaginian Galleys. C. Roman Galleys.)

Polybius says (Lib. I.): "When it was learned at Rome that the greater part of the crew belonging to the fleet had perished, either in the defense of the engines of war or in the operations of the siege, a draft of sailors was quickly made, and ten thousand sent to Sicily. They traversed the strait and reached camp by land. As soon as they had arrived, Consul Publius Claudius called the tribunes together, and told them that the occasion was favorable for attacking Drepana with the entire fleet; that Adherbal, general of the Carthaginians, to whom was confided the defense of that city, must think himself secure against such an undertaking; and that, not knowing that the Romans had received re-enforcements, he doubtless believed them incapable, after the losses that they had undergone, of setting out with their vessels. The tribunes shared the opinion of the Consul, and so the galleys were manned with the old and new crews, and volunteers, taken from among the best soldiers of the army, being seduced by hopes of rich booty after a short sail, embarked along with the rest.

Fig. 2.—MAP OF SICILY.

"All being thus arranged, the Roman fleet set sail at midnight, unbeknown to the Carthaginians, and followed the shore in silence, leaving land to the right. At daybreak the galleys of the vanguard were perceived from Deprana. Adherbal, very much surprised at their arrival, but at once comprehending the designs of the Consul, resolved to risk everything rather than allow the city to be besieged. He therefore hastily assembled the sailors upon the shore, and sent heralds to all quarters in order to convoke the mercenaries. As soon as all had assembled, he gave them to understand, in a few words, that if they desired to fight they could count on a victory, while that if they shrank before the present danger they would expose themselves to all the miseries of a siege. As they all showed themselves to be full of ardor, and asked to be led to the enemy, Adherbal congratulated them and ordered them to embark and follow his galley. He at once set sail, and led his fleet under the rocks that skirted the entrance to the port on the side opposite that by which the Romans were beginning to enter.

"Consul Publius, seeing that the Carthaginians, contrary to his expectations, were neither surprised nor frightened at his arrival, and that they were disposed to fight, gave orders to his galleys (some of which were already in the port, and others on their way thither) to put about, and make for the open sea. It resulted that between those that had crossed the pass and those that had reached it there was great confusion, followed not only by disorder among the crews, but also damage to the oars. Meanwhile the captains, in measure as the vessels became extricated, had them put into a line along the shore, with the rostrum toward the enemy. Publius, in his order of sailing, had placed himself in the last row, and it followed that, according to the formation that he had planned, he was at the extremity of the left wing.

"Adherbal, having taken five swift galleys, flanked the left of the Roman army, and then arranged his galleys in a line fronting the open sea. At the same time he sent orders to all the vessels that followed him to imitate his maneuvers. As soon as his whole fleet was thus formed, he gave the signal to advance against the enemy (Figs. 2 and 3). During this time the Romans remained along the shore awaiting the sortie of their last galleys from the port. From this it resulted that the Roman fleet, being inclosed between the enemy and the coast, fought at a great disadvantage.

"As soon as the two lines had drawn near one another, the prætorian galleys hoisted their flags, and the fight began. In the beginning the contest was nearly equal between the soldiers, who were the picked men of the two armies; but since the Carthaginians soon occupied a better position, the advantage began to turn in their favor. They excelled in quickness and in ease of evolution, because of the lightness of their keels and of the experience and skillfulness of their oarsmen. Having formed their line of battle toward the open sea, such galleys as became too closely pressed could easily retire to the rear of the line, because of their speed; while the Roman galleys, when they darted forward in pursuit of an adversary, and it afterward became necessary to fall back in order to avoid the oblique attacks of the enemy who surrounded them, turned sidewise, and in this position, heavy and badly maneuvered, received shocks that ended in sinking them. A large number was destroyed in this way. With the Carthaginians it was entirely otherwise: if one of their vessels was in danger, one of its neighbors came to its aid and towed it toward the open sea. As for the Romans, they were fighting too near land to move back, and when a galley was loaded in front and pushed by the prow, it stranded astern or broke on the reefs of the coast. The Romans could not attempt passages through the line, or an attack after an inversion of the ships that were already

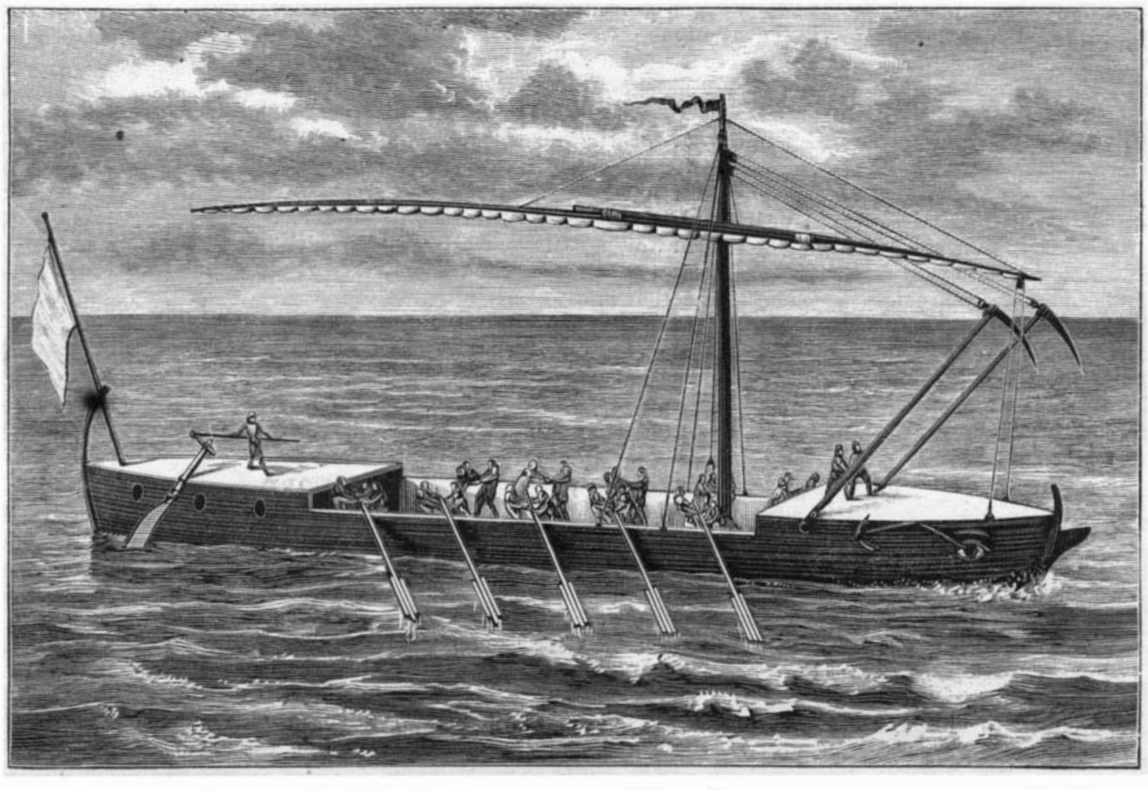

Fig. 1.—A ROMAN QUINQUEREME AT THE EPOCH OF THE BATTLE OF DREPANA.

engaged (maneuvers that are so important and efficacious), because of the heaviness of their keels and want of skill of their oarsmen; neither could they extend aid to those who were closely pressed, by crossing them astern, seeing that they were too near shore and that there was no room between them and land.

"The Consul, seeing that the battle was lost, and the majority of his galleys were stranded on the coast, escaped with thirty vessels of his left wing in keeping close to the shore. The Carthaginians took all the rest, ninety-three in number, with their crews, only a few men from which escaped by jumping ashore after the stranding of their vessels."

The foregoing narrative may be summed up as follows:

The Romans having suffered such losses that it was impossible for them either to continue the siege of Lilybæum or to menace Drepana, ceased all aggressive operations, and drew their quinqueremes ashore in the vicinity of their camps, A A (Fig. 2), so that they were unexposed to bad weather and the enterprises of Adherbal. In this situation Claudius received a re-enforcement of 10,000 men. Out of this number, raised in haste, we may suppose that 6,000 were ready to embark upon their arrival. To this 6,000 he added 3,000 sailors belonging to the old crews and 3,000 picked soldiers, and with this 12,000 men made up his armament of 123 galleys, which thus had complete crews and supplementary soldiers. At the approach of night he put his fleet upon the sea, and at one o'clock in the morning set out from the point, A′, hugging the shore and sailing slowly. His vessels, according to the custom of the times, were formed into a file by platoons. As the latter consisted of four galleys, and the interval between them was 262 feet (the minimum distance that permitted the file to pass to a line of battle), the length of the column was 9,184 feet, or about a mile and three-fifths.

At five o'clock in the morning, the speed being two knots per hour, the vanguard was at B, five miles from Drepana, and at this moment was sighted by the Carthaginians. Adherbal at once took his measures; he collected the crews, launched such of his galleys as had been hauled up to dry, and called together the mercenaries that were scattered throughout the city. At seven o'clock he set sail, ran by the walls of the city, and steered toward Columbaja, E, a rocky island that covers the entrance to the port. During this time the Roman galleys had increased their speed, and at seven o'clock the vanguard entered the port, P, leaving the island, I (Fig. 2), to the left. P. Claudius, who was in the rear guard, saw the movement of Adherbal's fleet, and, comprehending its import, ordered his galleys to put about, and tried to arrange them in line of battle. The combat took place along the line, I I (Fig. 2), under conditions and with results that we have seen.

All these facts in their entirety hold together admirably, and their probability is perfect on condition that the quinqueremes of both fleets in no wise resembled those of which Polybius (in his chapter on the battle of Ecnomos) has given the equipment. In fact, if each quinquereme had been provided with 500 men, the Consul could not have manned the 123 with less than 60,000 sailors and soldiers, inclusive of the volunteers. The 10,000 recruits derived from Rome would have been but a small complement, and Adherbal would not have dwelt in the confidence that P. Claudius supposed. On another hand, if quinqueremes of such dimensions had been hauled ashore, he could not have launched them without preparations and unbeknown to the Carthaginians. As for these latter, who, according to the Greek historian, were of the same strength as the Romans, it is clear that they could not, in two hours, have put 50,000 men into galleys which, even supposing them afloat, could not be manned rapidly, inasmuch as their draught was such that they could not be reached without the aid of row-boats. In whatever way we look at the operation against Drepana, all is easy and simple if we suppose the quinqueremes to have been barks; but all is impossible if they were large ships.

A comparison of the circumstances attending the battle of Chio with those of the battle of Drepana renders these conclusions still more obvious. At Chio we see old navies—fleets created by secular industries—in combat. If the cataphracts of Attalus, of Philip, and of Rhodes were barks, the narrative of Polybius has no longer any sense. At Drepana, on the contrary, as at Myle and Ecnomos, we find multitudes whose construction, movements, and enterprise are only comprehensible on the supposition that the unity was small.

There remains one difficulty. Polybius says (and no one challenges his testimony) that the Romans made their debut in naval construction with penteconters carrying 300 rowers and 120 soldiers, and that they built and armed 220 of these in three months, and that the battlefield of Ecnomos saw 700 galleys and 300,000 combatants. Are we obliged to believe this? Is a great historian by rights infallible? For my part, I think there are errors that must be fought, whatever be the name by which they are signed. In order to admire, it is necessary to understand, and great examples are useful to those only who believe in the possibility of following them.—*Rear Admiral Serre, in La Nature.*

Exhibition of American Goods in Chili.

In these days of overproduction and high tariff, when our manufacturers are surrounded, as it were, with a high wall which effectually prevents their leaving the country, it is gratifying to know that there exist nations, at least on the Spanish Main, that have confidence in our ability to compete with Europe in an open market. In a circular which lies before us, American manufacturers are cordially invited to exhibit their wares at a Permanent Exhibition of American Manufactures and Machinery soon to be opened at Santiago, Chili.

Speaking of the Chilian market, the circular says: "There are two obstacles which have hitherto prevented the development of our trade with Chili—one is our own high tariff, and the other is the lack of exact information in Chili as to the character and cost of our manufactures and machinery." It goes on to express surprise that of the $34,000,000 annual Chilian imports, the United States should have contributed only $2,000,000, one-half of which is represented by petroleum and lumber. Yet it is not so very surprising, nor are the causes which have led to the decline of our trade with Chili far to seek. Aside from tariff difficulties, which it is not the purpose of this article to discuss, there are other difficulties which make introduction of American goods difficult.

There is hardly a town in South America where European merchants are not to be found. These deal in European fabrics and manufactures from choice, and could hardly be expected to assist in demonstrating the excellence of American goods. As a result, the natives know little or nothing of them, and it is with a view of presenting them to their attention that the exhibition at Santiago is to be established.

There is a good reason to believe that a large quantity of American goods could even now find a market in Chili and other South American countries, if only their excellence could be demonstrated on the ground. It will interest the manufacturer to know that there is at present a large and greatly increased demand in Chili for cotton manufactures, agricultural and mining machinery, rolling stock, all kinds of hardware, furniture, scientific apparatus, canvas, and naval stores.

Americans have made great efforts in Mexico, and expended many millions in building railroads, yet the Chilian trade is almost twice as large as the Mexican.

Only a little over thirty years ago we had 25 per cent of the Chilian trade, but now only 4 per cent. Chili together with the whole South and Central American coast is a natural outlet for our products, and it is gratifying to see projects like this Permanent Exhibition of American Manufactures and Machinery set afloat with the commendable purpose of introducing American goods in a strange market.

Nickel on Zinc.

According to a process for nickelplating zinc, described in the *Journal of the Society of Chemical Industry*, the zinc is cleaned by dilute hydrochloric acid and thoroughly washed. It is then hung in the nickel bath for a short time, and on taking out is rinsed and thoroughly scraped, so removing all that does not adhere firmly. This is repeated till the zinc is covered with a thin film of nickel, which can afterward be made as thick as required. The suitable current strength is easily found. When the zinc is once thoroughly covered, the current may be increased without any risk of peeling off.

Friction.

M. Hirn communicates to the Academie des Sciences some observations on friction, with particular reference to machines and motors. He has arrived at the conclusion that there is a great difference between the friction of two surfaces sliding one upon the other, according as they are dry or separated by a layer of lubricating material. In the case of what he calls the *immediate* friction of bodies (*i. e.*, those surfaces which are dry), the coefficient of friction is independent of velocities, areas, or load. It is otherwise with the other order of sliding bodies, in which, as is generally the case, the surfaces are separated by an unctuous layer. Here the coefficient of friction is always a function of the velocity, the load, and the extent of the sliding surfaces. It is difficult to arrive at the exact laws which regulate the phenomena. The quantity of lubricant drawn under the rubbing surfaces by their movement, the temperature of the lubricant, etc., are capable of modifying the value of the coefficient of friction many times in the course of a single experiment.

It may be broadly stated that, in the general condition of ordinary machines, the power necessary to overcome friction is proportional to the square roots of the sliding surfaces and of the load, and (when the lubrication is abundant) to the velocity. The influence of velocity is above all complex. With great velocities, or at least when the loads are light in comparison with the frictional surfaces, a great number of liquids very different from oils or fats become lubricants. Air, under certain conditions, and when brought in sufficient quantity between the sliding surfaces, becomes the best of lubricants; the coefficient of friction being thereby reduced to one ten-thousandth. When, on the contrary, the speed is too low, or the load relatively too heavy, the unctuous matter may be expelled. The friction then becomes immediate, with a coefficient rising to one one-hundredth or one-fifth. M. Hirn points out that these views are supported by some observations of M. Deprez, who found that the coefficient of friction of a given machine, determined for a certain velocity and state of lubrication, diminished as the speed increased and the oil became warm; while, when the velocity was much diminished, the lubricant was no longer drawn between the surfaces in sufficient quantity, and the contact became as metal to metal.

Electric Lights for Private Dwellings.

Perhaps the most perfect method of utilizing electricity for household purposes is the installation recently put in at the residence of Mr. E. H. Johnson, in this city, President of the "Edison Company for Isolated Lighting." Arranged in one corner of the house cellar is a 30 horse power engine running noiselessly at a speed of 290 revolutions per minute, connected by an 8 inch belt with an Edison dynamo of sufficient capacity to illuminate three city dwelling houses from top to bottom.

Wires lead from this machine to the various rooms of Mr. Johnson's house. Each floor is provided with a separate set of wires, safety plugs, and switches, and any chandelier or part of a chandelier may be instantly lighted or extinguished at pleasure. The exhaust steam of the engine is utilized to heat radiators in the cellar inclosed in air boxes, and heat the cold air, causing it to ascend the original hot air flues built in the house.

The condensed water from the radiators is returned to the boiler by a pump. When in full motion, the engine makes no noise that can be heard above the cellar. In the cellar the only sound was that of a slight flapping of the belt upon the engine pulley, and this Mr. Johnson expects to eliminate by the employment of a rope belt.

Fixed in one corner of a billiard room in the basement was an Edison automatic circuit regulator, consisting of a device for automatically switching in or out more or less resistance coils to balance a few or large number of lamps. It was extremely sensitive, and operated rapidly. From the regulator two main wires ascend through the house with branches at each floor. Fireplaces in the different rooms were illuminated by a series of incandescent lamps, covered with small pieces of pink and red tissue paper, the appearance of which at a short distance closely resembled a glowing coal grate fire.

The advantage the light possesses of illuminating pictures was shown by suspending a lamp in the interior of a large painted porcelain vase; the picture stood out in fine relief. It has been found that colored glass globes for incandescent lights retain an increased amount of heat, and that a softer and more diffused colored light can be obtained by stretching over the glass a piece of colored tissue paper or silk fabric. The lamps in theaters are modulated in this way; the changes of colored lights on the stage being effected instantly, and with as much facility as with gas.

To illustrate some of the advantages of having an abundance of electricity in one's home, Mr. Johnson devised a method of illuminating at intervals a Christmas tree with myriads of different colored lamps. He had made specially a large number of small incandescent lamps of 3 candle power each, covered with different colored silk bags; these were strung in vertical rows from the bottom to the top of the tree, a series of 4 rows being connected to one conducting copper plate embedded horizontally in the bottom portion of the trunk of the tree. The upper ends of the series were connected to the opposite wire. There were six conducting copper plates on the trunk of the tree, three being arranged to be connected with one pole of the dynamo; the other three with opposite pole. The same current which produced the light also propelled a small motor geared with cog wheels, and located under the platform.

When the switch was turned on, the motor revolved the tree noiselessly and at a slow, uniform speed; at the same time connection was alternately made with the conducting plates on the tree trunk, thereby causing the miniature colored lamps over the surface of the tree to become alternately lighted and extinguished, from twenty to forty at a time. The constant changing of colored lights, combined with the rotary motion of the tree, produced a very novel and beautiful effect, which was enhanced as one saw it reflected in an adjacent mirror.

The quietness which prevailed throughout the house was of itself a surprise to many when told that a 30 horse power engine was running at a high speed in the basement; and it proved conclusively that a decided advance has been lately made in isolated electric lighting.

* * *

OYSTERS are reported to be good for dyspeptics. They never produce indigestion, and are preferred by invalids when all other food disagrees with them. Raw oysters are used by singers for hoarseness.

The Identification of Minerals.*

A person's first thought on picking up some unknown mineral or rock from the roadside, the quarry, or the field, is, What is this? What is the name of this object? and, if he has no more knowledge of the mineral world than the majority of people, he will be unable to answer his query, unless the specimen should chance to be quartz, mica, or some such very common mineral.

After the student of mineralogy has advanced far enough in his studies to become somewhat familiar with the subject, he begins to ask himself, when examining some fragment of the mineral kingdom, Of what is this object made? What is its composition? and lastly occurs the question, How was it made? This article concerns itself only with the first of these three questions. It is well, perhaps, to say here that, in order to acquire a knowledge of the physical peculiarities of minerals sufficient for their identification, the student should familiarize himself, by frequent inspection, with the general appearance of all minerals that come under his observation, and especially the more common species, as quartz, feldspar, mica, hornblende, limestone, etc. It is very desirable for the amateur geologist to have a collection of his own, of typical specimens of fifty or a hundred of the more common minerals and rocks, which, by the way, costs very little. If this is not convenient, he should not fail to visit the mineralogical collection in the rooms of some natural history society, which contains, in addition to all the common minerals, many rare and beautiful specimens from all parts of the world. It is only by careful study of the specimens themselves, object lessons, as it were, that any substantial knowledge of them can be gained.

Minerals are identified, or determined, as mineralogists say, by first noting their physical peculiarities, and afterward ascertaining their chemical composition.

We will now consider the physical characters of minerals:

1. About the first characteristic of a mineral to engage our attention, is its color. Colors, as relating to minerals, are of two kinds, essential and non-essential. The essential color of a mineral is its color when in a pure state. The non-essential is mainly the color of the impurities contained in the mineral. The essential color is found by powdering the mineral or rubbing it on any hard surface, as unglazed porcelain. The powder thus obtained is called the streak, and although the non-essential color may vary greatly, its streak is always nearly uniform. A mineral shows its true color when powdered, for the same reason that muddy water becomes white when beaten into foam and made opaque.

The essential color or streak of limestone is white or grayish white; its non-essential colors range from red, green, and yellow to blue, brown, and black. Common feldspar (orthoclase) may be white, gray, flesh red, or even green, as in Amazon stone; but its streak is uncolored.

Metallic minerals, those in which metallic elements predominate, are always opaque, and generally have essential colors, while vitreous or glassy minerals, which are more or less transparent, often have non-essential colors, because we can see into them and discern the impurities. Magnetite (an ore of iron) is a metallic mineral, and its color and streak are both black.

2. Closely related to color is the property termed luster, by which is meant the quality of the light reflected by a mineral as determined by the character of its surface. The two principal kinds of luster are the metallic and vitreous. The former is the luster of all true metals, and of nearly all minerals which are chiefly composed of metallic elements. An example may be seen in galena. The vitreous luster is the luster of minerals in which the non-metallic elements preponderate, as in vitreous quartz. There are various other kinds of luster, as adamantine, the luster of the diamond; resinous, the luster of resin; pearly, like pearl, as talc, pearl spar; and silky, as satin spar. When luster is entirely wanting, a mineral is said to de dull, as chalk and kaolin.

3. After the color, streak, and luster have been determined, the hardness is the next property that commands attention. In minerals there are all grades of hardness, from talc, which is impressible by the finger nail, to the diamond, the hardest of all known substances. To facilitate the determination of this characteristic a scale of hardness has been devised, as follows, beginning with the softest:

1. Talc.
2. Gypsum.
3. Calcite.
4. Fluorite.
5. Apatite.
6. Othoclase.
7. Quartz.
8. Beryl or Topaz.
9. Corundum.
10. Diamond.

Of any two minerals that which scratches the other is the harder, and by testing an unknown mineral by those given in this scale its degree of hardness can be ascertained. For instance, if we have a specimen that scratches calcite, but is scratched by apatite, we estimate its hardness at 4, but if it should also be scratched by fluorite, we would place it at 3·5. The hardness of all common minerals, however, as nearly as we need to get it in order to identify them, can generally be determined without recourse to the scale. The hardness of common window glass is about 6·5, and any mineral that will scratch it must be at least as hard as quartz; and any mineral that can be scratched by a knife cannot be much harder than 5·5. By the judicious use of the point of a knife and a piece of glass one can soon learn to estimate hardness well enough for practical purposes. In general, different specimens of the same mineral vary but little in hardness. There are exceptions to this rule, however, and some mineral species, as serpentine and calcite, vary greatly in this respect; the former ranging from 2·5 to 5·5, and the latter from 1 to 3·5.

4. The specific gravity or weight of minerals is one of their most constant characteristics. It is more difficult to discover, however, than hardness, and is therefore of less practical value as an aid in determining species. If the specimen is not too small, its weight can generally be estimated with sufficient accuracy for practical purposes by lifting it in the hand. Barytes or heavy spar can be readily distinguished from all minerals which it otherwise resembles by its much greater weight.

5. Most minerals occur more or less commonly in crystals, that is, in figures bounded by plane surfaces arranged regularly about a center. Minerals of the same species always crystallize in similar or allied shapes, and therefore the determination of the crystalline form is an important aid in identification. For instance, iron pyrites commonly crystallizes in cubes, thus rendering it easy to distinguish it from copper pyrites, which it sometimes resembles. Tourmaline and hornblende, when occurring in small fragments in rocks, are very similar in appearance, but the tourmaline can usually be distinguished by its long, slender, triangular crystals. In order to recognize any but the simpler forms of crystals a knowledge of crystallography, the science "which treats of the forms resulting from crystallization," is necessary, but as most minerals commonly occur uncrystallized, we are often obliged to depend upon other characteristics, and the determination of the crystalline form is seldom absolutely necessary.

6. Cleavage, or the tendency of a mineral to break along certain planes, is a property closely allied to the crystalline form, and is frequently useful in the identification of minerals. Common feldspar (orthoclase) can be distinguished from similar minerals by its peculiarity of breaking or cleaving in certain directions with a bright, even surface.

7. When a mineral does not occur, as is commonly the case, in distinct crystals, its general structure should be noted, whether it consists of an aggregate of fine grains like granular quartz, or forms a compact mass like flint or chalcedony. Notice if it is made up of a number of slender columns like some tourmaline, or of fine fibers like asbestos or satin spar. Sometimes a mineral has a lamellar structure, consisting of a succession of plates or leaves, like common mica. Again, it may be found in globular forms like marcasite (white iron pyrites), or in a shape resembling a bunch of grapes, termed botryoidal, like limonite or chalcedony. Minerals also occur coralloidal (coral-like) forms, as aragonite, or dendritic (tree-like) shapes, as magnetite (magnetic iron ore). Other species occur in stalactites or stalagmites, as limestone.

There are also many other imitative shapes in which minerals are found, such as amygdaloidal (almond shaped), reniform (kidney shaped), capillary (resembling a thread or hair), reticulated (net-like), acicular (resembling a needle), etc. In short, a careful examination of the general structure and imitative shape, if any, of a mineral will often lead to its identification without further trouble.

8. There are various other physical characters of minerals, such as magnetism, taste, odor, feel, tenacity, and phosphorescence, that are often useful in their determination. For instance, magnetite can be distinguished from minerals which it otherwise resembles by its property of being attractable by a magnet or magnetized knife blade; native alum by its astringent taste; kaolin or clay by its peculiar odor; and the hydrous silicates—talc, serpentine, and chloride—by their smooth or greasy feel. When two pieces of quartz are rubbed against each other they will emit light, or are phosphorescent. This is best seen in the dark.

The determination of the physical characters of minerals is, generally speaking, sufficient for the identification of all common, and also many uncommon, species, but there are many others that need to be tested chemically before their identification is rendered certain. This treatment is also necessary when the chemical composition of the mineral is to be ascertained, or the exact proportion of metal in an ore of silver, lead, copper, etc., determined. This latter process is called assaying.

We will now speak of the chemical characters of minerals.

Treating the mineral with acid is usually the first step. Calcite or common limestone can be readily recognized by its lively effervescence when touched with hydrochloric (muriatic) acid, while in the mass, but dolomite or magnesian limestone will only effervesce when powdered. Other minerals require the use of strong or hot acid. In addition to hydrochloric, sulphuric and nitric acids are often used. By the employment of acids the degree of solubility is determined, the presence of carbonic acid detected, and various other results obtained. After treatment with acids come the blowpipe tests. The mineral is placed upon charcoal, and submitted to the action of the flame of an alcohol lamp or gas jet directed upon it by the blowpipe. The degree of fusibility is noticed, the color of the flame noted, and also the character of the sublimates and the odor of the escaping gases. The mineral is heated in open and closed glass tubes, and then mixed with the fluxes—soda, borax, and salt of phosphorus. By these and other methods of treatment, and reference to a set of tables on the determination of mineral species, the exact status of the specimen in hand is finally decided.

The quantitative analysis of minerals, by which the precise proportion of each of their chemical constituents is found, requires a still more careful examination and additional treatment. A few words on the identification of rocks will not, perhaps, be out of place. To ascertain the peculiar species to which a rock belongs, it is only necessary to identify its constituent minerals, as, if we find a rock to consist of an aggregate of the minerals quartz and orthoclase promiscuously intermingled, we know it to be a binary granite; if it contains hornblende in addition, it is hornblendic granite. If a rock is composed of quartz and mica, it is mica schist; if a combination of hornblende and quartz, it is hornblende schist, and if it is simply a mass of grains of quartz firmly cemented together, we call it quartzite.

Many rocks, however, are so fine grained that it is impossible to distinguish the minerals of which they are made up, with the unaided eye. In such cases recourse is had to the microscope, which generally reveals the character of the constituent minerals without further trouble, but quite often we are obliged to go still further, and cut off a thin section or slice of the rock. This slice is mounted on a slide and carefully examined with the microscope, notice being taken of the reflected, transmitted, and polarized light, change of color, and various other peculiarities. The object is to ascertain the crystalline form, if any, of the minute particles of the minerals constituting the rock, the color, luster, and any other character possible. The science which treats of the determination of rocks by this method is termed microscopic lithology. Most specimens, however, can be identified without the aid of the microscope, so that a knowledge of this branch of the science of rocks is not indispensable to the amateur geologist.

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A New Method of Preserving Hops.

The deterioration which hops undergo when stored under existing circumstances is well known, and is a serious loss to hop merchants and brewers, and many have been the attempts to devise a method of keeping hops, or of extracting their essential principles. Unfortunately, all preserved hops and so-called hop extracts are deficient in some constituents, and have never been in favor or come into general use among the brewers of this country.

A new method of extracting and preserving the essential principles of hops has lately been devised by M. Louis Boule, of Bourges, and the brewers of Belgium and the North of France have, says the *Brewers' Guardian*, already begun to avail themselves of the invention. It is well known that the fragrant aroma of the hop is for the most part contained in certain small glands, which can be separated from the rest of the hop flower, and which when separated constitute a yellow powder known as "lupuline;" this powder very easily undergoes decomposition, and the oil of hops, with which it is saturated, soon becomes oxidized in contact with the air, giving rise to valerianic acid, which imparts that unpleasant and "cheesy" smell to old hops. M. Boule proposes to mechanically separate this lupuline by the aid of a centrifugal machine, and to keep the powder in vessels completely protected from the air. Afterward the hops, which still retain all the bitter principle, tannic acid, and other useful soluble matters, are extracted by prolonged boiling with water, and this extract is subsequently evaporated and concentrated *in vacuo* at a temperature not exceeding 125° Fah. This extract is subsequently mixed with its proper proportion of lupuline, and the mixture is then placed and kept in airtight cans, much in the same way as our preserved foods are kept.

This preparation, which the inventor calls "normal hops," contains the whole of the extract—both volatile and fixed—of the hops, and can be kept unchanged for an indefinite period. The idea is that brewers should send their hops to be extracted in the manner we have indicated at special factories established for the purpose, and then have returned to them the whole of the essential principles in a concentrated and perfectly stable form.

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BEHOLD, says a contemporary, referring to the exhaustless supply of petroleum and natural gas, what a few little holes in the ground can accomplish!

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* W. H. L., in *Kansas City Review of Science*.