ROMAN CITIES OF NORTHERN AFRICA.

RELICS OF AN ANCIENT CIVILIZATION.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

DURING recent years parts of northern Africa, bordering the Mediterranean, have proved a rich mine for archaeologists. Separated only by the sea from Italy, the shores of Tunis and Algeria at an early date fell under Roman domination. Wealthy cities sprang up at important points, and retained their civic life for centuries. After hundreds of years of barbarous rule these coast countries have come under the influence of France, and French archaeologists have done notable work in excavating and protecting their remains of ancient civilization. Many objects of interest are preserved in museums at Tunis and Carthage. Some of these are illustrated here; but it is not as a mere mine of "curios" these shores are excavated. From this point of view Tunis is much inferior to Egypt. In the latter country several causes, such as the continuity of the priestly rule for centuries, the reverence to the dead, and the custom of endeavoring to render things imperishable, have combined to leave very full records for the present day. In Tunis, on the other hand, a change of rule was frequent; and with the changes cities were sacked, either swiftly by a mob of soldiery, or more slowly though none the less surely by the inhabitants or others, who demolished old buildings to provide materials for new ones.

Within the last few years the French have done much work at Timgad, a Tunisian city, with encouraging results. The city has suffered from the plundering of two classes of builders, but still retains the unmistakable mark of its Roman origin. The more ambitious of the spoilers carried away marble pillars and carved stonework, appreciating their value. Thus, medieval Venice was largely built and decorated with the plunder of ancient cities. The second class of spoilers merely took the most accessible stones with which to build their own huts or sheds in the neighborhood. They had a habit of picking out the courses of dressed stone to a convenient height from the ground—usually not more than six or eight feet—and leaving an undermined, topheavy superstructure, which sooner or later fell to the ground.

Timgad is unique of its kind, and nowhere else do we find a buried city which bears such a close analogy to Pompeii. It is a city of large extent, buried by the sands in the course of time, and a large part of it is now uncovered, showing the principal streets, its forum, temples, public baths, and dwelling houses, over a wide tract. We have previously given some general views of this city and at present we refer principally to the more recent excavations.

One of the largest of the private dwellings is known as the House of the Garden. Its principal entry gives access to a vestibule, and from this the atrium opens opposite the entrance, and a room on either side. The latter rooms are situated so as to face upon the portico which passes along the main street in front of the house. In the central part of the house is an interior court which has a colonnade around the four sides. What is somewhat peculiar is that the court is partly surrounded by a raised artificial garden. This is formed by an inclosure of stone so as to hold the earth. A series of upright flags was placed around the court just outside of the columns of the portico, and at some distance in front was a second series to allow the intervening space to be filled with earth, and here were no doubt planted flowers and plants. The outer facing of stone is not a straight surface, but is formed of a series of outwardly projecting arcs like bay-windows, so as to give a more ornamental effect. Built with the wall of the garden beds was a series of square stone columns which rose to a certain height, and were topped with ornaments such as double heads or tragic masks. In the court is a well about ten feet deep. At the top it had a well-head of stone, like those which are to be seen at Pompeii. In one of the rooms opening from the atrium is found a mosaic floor in white, blue and yellow pieces. The *tablinum* has a larger and better executed mosaic floor, showing a flower and leaf pattern of good execution. As the present house lies in that part of the town which is reserved for public buildings, it is thought that it was the dwelling of a magistrate or other official person.

In Timgad the houses are in a much damaged condition, and are rarely to be found intact, as occurs in Pompeii. After suffering much from plunder, the city was finally abandoned and in the course of ages became filled up by the drifting sands. In carrying out the excavations a great deal of work had to be done in consolidating and partly restoring the walls of the houses. This was done for a few feet in height and then the upper surface of the wall was flattened off so as to give a finished surface. The city was certainly inhabited after its destruction by the Berbers in 535 A. D., if not by the Byzantines or the Imperial

soldiers, at least by the natives or the degenerate descendants of the Romans, who modified the arrangement of the houses, and used material which they took from the older constructions. It may be noted that at Timgad the houses, at least the larger ones, were spaced apart and not built together as we find at Pompeii. Most of the streets lying within the city walls were placed at right angles and at regular distances upon a very methodical plan and in this respect it resembles a modern town. This is owing to the fact that Timgad was built according to a pre-conceived idea and at one time. Under the streets, most of which are paved with large flag stones, are found sewers of great size and in some of them a man can walk upright.

During the Byzantine period a number of basilica were erected, and at least seven of these ruins are found in the city. One of the largest is the church which is illustrated here, which covers a large area of ground. The basilica included a court which communicated with the street, and also several annexed buildings. The nave was about forty feet in length and a series of columns separate it from the side aisles. Some of the Roman ruins furnished the columns, as often happened in like cases. The altar table was formed of red marble. The paving of the main court was in large flagstones. Behind the apse were found a number of sarcophagi of wealthy persons.

One of these is formed from a single stone and is decorated with a molding; the others are built of a rough masonry. A gate leads from the church to a narrow gallery surrounding a court built after the manner of an atrium whose four porticos are upheld by columns. This atrium was used in the present construction as the baptistry, and seems to have belonged to a still more ancient basilica. In the center of the court is the compluvium, in the form of a circular basin provided with three steps leading to it, and four light columns upheld a roof over the basin. Adjoining the basilica is a very large and handsome dwelling, and it is somewhat built into the church. Much of its material was used in the construction of the latter. The atrium of the house served as a burial place connected with the church, and here we find a number of sarcophagi ornamented with Christian emblems.

No less than six public baths, some of considerable size, have been found up to the present. The baths which lie in the northern part are the largest, and they are situated outside of Trajan's wall. Here the ruins of the building have the walls no less than twenty feet in height in places, and the structure measures 250 by 210 feet. Four main doors open into it, and in the center of the building are the main halls, three in number, around which are ranged all the other parts of the baths. These large halls were used as promenades or for games or gymnastic exercises. One of these halls is 80 by 60 feet and was originally decorated in a very handsome manner. There are a great number of rooms for hot and cold baths, laid out upon the usual plan of the Roman baths, such as are found in Pompeii.

A great number of objects coming from the region of Tunis are now placed in the museum which was founded not many years ago at the Bardo Palace in the outskirts of Tunis. This was originally the Beys' Palace, and even yet it contains a number of handsomely decorated and furnished rooms which belong officially to the Bey Mohammed-es-Sadok, but as he now inhabits a villa at Marsa, on the site of Carthage, the Bardo Palace is scarcely used except on state occasions. A number of rooms have been occupied by the new museum. There is now a large museum on the site of Carthage itself in which are placed all the finds coming from the Rev. P. Delattre's excavations. This latter collection is a much larger one than that at Tunis, for objects are being added to it continually.

One of our illustrations shows a view in one of the principal rooms of the Bardo museum, and the objects, consisting mainly of mosaics and statues, are tastefully arranged. Nearly the whole floor is covered by a great mosaic which is one of the largest discovered. It was found at Sousse, the ancient Roman town of Hadrumetum, and the subject represents the Cortège of Neptune. In the center is shown Neptune upon his car, while there are a great number of medallions in which are placed various sea-deities and other subjects. This mosaic is very well executed and shows a variety of brilliant colors and the figures have a lifelike appearance. Upon the walls are a great number of mosaics which come from tombs. The subjects present scenes from real life, including animals, birds, and fish.

VITAL RHYTHM.

By Dr. A. DRZEWINA.

THE importance of habit in biological phenomena is so evident that life may almost be said to consist of habit. In the physiology of man, animals, even plants, habit establishes a definite rhythm which dominates the life of the creature. If chestnut trees of the variety known in France as "March 20th" bloom a month in advance of the rest of the species, it is because former conditions of life have impressed upon this variety a particular seasonal rhythm, which has since been maintained by a sort of habit, independently of the conditions which caused it. The example of spring wheat is equally instructive. Wheat which had been cultivated in the south of Germany and had acquired the seasonal habits appropriate to that region was sown in Scandinavia. It adapted itself so rapidly to the northern climate that in a few years a variety of wheat was developed which had acquired a habit of maturing much more rapidly than its German ancestor and retained this habit when it was sown in southern Germany. Thus was produced a variety of wheat which, though sown in spring, ripens as early as winter wheat sown in the preceding autumn.

The life of littoral, or seashore, animals, is intimately connected with, and to some degree regulated by, the ebb and flow of the tide. As the tidal movements are rhythmical, the animals show a rhythm of the same period, which persists for some time after their withdrawal from the influence of the tide. This has been proved by recent experiments of Bohn on sea anemones, annelid worms, and mollusks.

Convoluta roscoffensis is a little ciliated worm found on the beaches of Brittany, where it forms vast bright green patches of incessantly varying shape and size. These colonies are submerged for about two hours before and two hours after high tide. At this period the worms bury themselves in the sand to escape the buffeting of the waves. When the tide ebbs, they reappear on the surface of the sand. These alternate movements, evidently acquired, have in the course of generations become independent and spontaneous, so that they are continued in the aquarium where there are neither waves nor tides. The worms, imprisoned in a glass tube with wet sand, move to the top of the tube at low tide and to the bottom at high tide. They even follow the irregularities of the tide, moving slowly at neap tide and quickly at spring tide. These alternating movements continue for several days after the worms have been taken from the beach.

Littorina rudis, a very common gasteropod, is found retracted into its shell at neap tides in summer when the rocks on which it dwells are strongly heated by the sun and not submerged for days. On the coming of the spring tide, which covers the rocks twice daily, the mollusks emerge from their semi-torpid state and crawl about on the wet rocks, seeking the darkest places. This vital periodicity, due to the movements of the tide, persists after the mollusks have been removed from their natural habitat. If they are placed, while in the torpid state, in an evaporating dish, they suddenly awake and move with unerring precision toward the shaded part of the vessel when the tide reaches their native rocks, although they have had no bath to relieve their desiccation and wash away the waste products to which their auto-intoxication and stupor are due. In addition to this fortnightly rhythm they exhibit a rhythm of smaller amplitude and of the ordinary tidal period.

A vital periodicity of the same character, and equally persistent, is observed in the sea anemone (*Actinia*), though not invariably. In general, the vital rhythm in littoral animals is more or less strongly marked in proportion to the sharpness of the contrast between the conditions of existence at high and low tide. Anemones living in the pools of water that are left by the receding tide are subjected to little, if any, desiccation and consequently they cannot exhibit any striking tidal periodicity. But anemones living on rocks which are exposed at low tide and submerged at high tide show a clearly marked periodicity. In this case, also, the vital rhythm is manifested in the aquarium, where the anemones, though always submerged, close spontaneously at the hour of low water and gradually open as the tide rises.

A similar vital rhythm has been observed in the vegetable kingdom. According to the recent observations of Fauvel and Bohn, *Pleurosigma aestuarii*, a marine alga of the diatom family, behaves much like the *convoluta* worm under the influence of the tides. At high water these microscopic organisms lie buried in the sand, but at low tide they emerge and form a thick brown layer on the surface. When the diatoms are transferred to the aquarium there is a con-

dict between the tidal rhythm and phototropism, or tendency to seek the light. At night they remain buried through all changes of the tide. Hence they emerge either once or twice in each twenty-four hours according to the number of low tides in daylight.

Some biologists have endeavored to explain these curious phenomena by assuming the existence of a

"memory of the tide," and Forel has attributed a "memory of time" to bees which, according to his observations, invade the dining room at the hours of those meals at which sweets are served, but at no other time. But, though bees and even annelid worms may possess some sort of memory, it would be absurd to ascribe memory to diatoms, which show not

the slightest trace of a nervous system. Bohn simply records the facts, without attempting any explanation, either mechanical or psychological. Le Dantec groups the phenomena under the title "habit," which explains nothing but is convenient for the classification of facts.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science aux XXme Siècle.

THE MEASURELESS REMOTENESS OF THE STARS.*

THE SCALE OF THE STELLAR UNIVERSE.

BY J. F. LANNEAU.

IN February, 1901, there suddenly appeared in the northern sky a previously unseen star about as bright as the familiar Pole star. It quickly brightened, and in less than three days vied with Sirius, the brightest of the stars. Then, fading rapidly for a month, it resumed its former invisibility. The sudden blazing up of that star to a 25,000-fold brightness, really occurred over three centuries ago—occurred before Jamestown's settlement, whose tercentennial is now being celebrated. Such that star's distance, that its light flashing from its unthinkable remoteness had just reached us in February, 1901!

Most of us think we can see a countless multitude of stars. But contrary to this popular impression, the visible stars are really quite limited in number. They have been carefully counted and found to be, all told, less than 7,000. Of course the telescope brings into view millions more—a countless host. But even from a favorable standpoint on the earth's equator, scanning the evening sky from pole to pole throughout the year as its twinkling lights pass in review, we cannot count as many as 7,000 stars. Of the half of them in the sky any night some 1,500 are concealed by the murky air all around the horizon. At no time can an observer see more than 2,000 stars.

How far off are the stars? Too far to state in miles. To name the distance to the nearest star in miles, would be like stating the distance to the moon in inches. For stellar remoteness we need a large unit—not less than the distance from the earth to the sun. Some hundreds of thousands of this long unit express somewhat intelligibly the star's distance from us—provided the unit distance is comprehended.

Unfortunately, any mental picture of this earth-sun unit distance must be inadequate. We may aid imagination, however, by noting the time of transit of some missile or swift vehicle.

A balloon soaring sunward may aid conception. Assume that Columbus in the year 1492, to signalize his discovery of America, had sent up a balloon to the overhead sun; and suppose that, regardless of failing atmosphere, it rose swiftly, steadily 37 1-3 miles every hour until it reached the sun. When did it reach its destination?

Columbus retraced his uncertain course across the broad Atlantic, presenting the new-found western continent to Ferdinand and Isabella. He made other long voyages—other discoveries. Still the balloon was swiftly mounting sunward! More than a century passed. Jamestown was settled. Virginia's forest witnessed the romance of Pocahontas. The "Mayflower" landed at Plymouth Rock; and later, New England nestled in the wilderness. Lexington's guns heralded a new flag—the stars and stripes. Independence was declared. Then, late in the new nation's natal year, the balloon which had mounted steadily sunward 37 1-3 miles every hour for wellnigh three centuries had just reached the sun. Its long flight measured our needed unit of distance; 275,000 times this unit is the distance to the nearest star—the bright southern star α Centauri. What then the distance to the stars beyond? What the distance to those so remote in the depths of space that powerful telescopes bring them only faintly into view?

For these stupendous distances our earth-sun unit—the 93 million mile unit—is too short. For these staggering stellar reaches through boundless space, a special new unit of length must be devised. It is called the light-year—meaning the distance light flashes in a year.

We must realize if possible, something of the significance of this unit—the distance light goes in a year.

The first creation from primal chaos was light. "Let light be, and light was." It moves with the swiftest speed known. Its unrivaled velocity—first learned in 1675 by noting eclipses of Jupiter's moons, more recently proved experimentally—is 186,330 miles per second; this distance is over seven times the distance around the world. If a light ray, instead of moving as it does in a straight line could trace a circle, it would flash seven times around the world in a second. Yet, at its unrivaled rate, light in one

year traverses less than a fourth of the distance to the nearest star, for α Centauri's distance from us is over four light-years.

Sirius, the brightest of the stars, is eight light-years from us; Arcturus, 24 light-years; and Polaris, the familiar north star, is 60 light-years distant.

Some of the stars just visible to the unaided eye are more than 300 light-years distant from us. Many of those which are faintly seen through a large telescope are 3,000 light-years off; and others are at distances of many thousand light-years. With this insight into the vastness of stellar reaches we may in some degree understand that any two visible stars, though seemingly side by side in the sky, are in reality distant from each other several light-years, and that the stars are not crowded. Their seeming nearness to each other is but the effect of distance. Closely grouped apparently, as in Perseus or Scorpio, or in any of the constellations, no two stars are really neighbors. Any two of them, on the average, are twice as far apart as are the earth and the nearest star. Often the two apparent companions are nearly in the line of sight—one far beyond the other. For instance, in the northern constellation Cassiopeia are two faint stars, Eta and Mu, seemingly side by side; one is distant from us 21 light-years; the other, 9 light-years. The two, then, seemingly close neighbors, are in reality separated a distance of at least 12 light-years—about three times our distance from the star α Centauri.

The familiar Big Dipper is outlined by seven stars: three in a curve trace its handle, and four its bowl—the two farthest from the handle pointing to the North Star. Could we stand on any one of the seven stars in that group, the nearest of the others would appear to us about as the star Sirius appears from the earth.

We speak of the "fixed" stars in contradistinction to the planets. But the stars are not even relatively fixed; they are in motion, and in all directions; each in its independent course in swift, steady motion. They are certainly changing their relative positions, and the changes are not perceived simply because of what has been noted—their inconceivable distances from us and from each other. Incontestable proof of their real, though to us imperceptible change, is found in comparing star charts made long centuries ago with charts recently made. For instance, the bright star Sirius mapped by Ptolemy seventeen centuries ago, is shown by modern charts to have moved southward about the apparent breadth of the full moon.

A moon-breadth in seventeen centuries! Yes, but a moon-breadth at our moon's distance is two thousand miles; at our sun's distance, nearly a million miles; and at Sirius' distance, a moon-breadth is hundreds of thousands of millions of miles!

Viewed through a telescope a star seems to be a mere point of light. The larger the telescope, the more of the star's light entering its great eye, the brighter the star's image, but the image is still a point. The star's really vast volume, millions-fold larger than this earth, seemingly shrinks to a mere bright speck because of its inexpressible remoteness from us. How can it so shine from the profound depths of space? Does it receive light from the sun and reflect that light to us as do the planets? Is the star's light only reflected sunlight? No; each star, as the spectroscope proves, shines by its own energy—is itself a sun. Our sun and those remote twinkling stars reveal the same essential structure. Each star is indeed an immense glowing body, dispensing freely its own heat and light. Some of them—notably Canopus and Arcturus—are vaster in volume than the sun. Could the sun withdraw from us and retreat into the depths of space, on its way to one of those remote stars it would itself become a star and grow fainter and fainter until invisible. Our sun, like these other stars, is speeding through space; it is advancing toward Hercules—or more nearly, toward the bright star Vega, now conspicuous in the northeast. The spectroscope confirms this fact. Moreover, it shows that the sun's steady motion toward Vega is at the rate of some twelve miles a second. In a year, we move in that direction four times the earth-sun distance, and in some four thousand centuries we will reach Vega's

present region of space—but not Vega. Its motion meanwhile will have borne it to new remoteness. We shall then have a new pole-star, but shall still see in the north the same Big Dipper—a little bent doubtless—and the same Galaxy, the same Zodiac, the same glittering constellations as we do now.

That since the "Beginning" we, with the sun, have been steadily speeding on and on through interstellar space without once meeting or passing a single lonely star, brings home to our realization as no other consideration can, the amazing amplitude of cosmic space, the completeness of the isolation of each star from all others, the supreme magnificence of the scale of the stellar universe.

UTILIZATION OF BOOKBINDERS' WASTE.

BOOKBINDERS' waste can be profitably used for the production of papier maché for bas reliefs, vases, urns, frames, clock cases, etc. All kinds of paper cuttings, or pasteboard residues, can be employed. The other ingredients are finely sifted ashes, particularly of hardwood, and flour paste. The papier maché is made as follows:

The refuse is reduced to small fragments, placed in a vessel filled with water and left to dissolve. When thoroughly soaked the water is lightly pressed out of the mass which is placed in a mortar and well pounded. After this, the mass is placed in a strong linen cloth and as much of the water wrung out as possible. The balls thus produced are dried, either in the sun, or at the fire. The dried balls are rubbed on a rasp so that the flocks produced are like cotton to the touch. These flocks are then mixed with flour paste on a board with a wooden spatula into a dough. This dough, which forms one-third of the mass to be prepared, is arranged in a ring, with twice its bulk of finely sifted ashes in the center. Water is added, a little at a time, mixing gradually, until all the ashes are wetted. Finally, the ring is incorporated with the wetted ashes.

This mixture is placed in the mortar and well pounded, yielding the papier maché ready for use. If it is desired to keep it moist for a long time, it can be placed in glazed earthenware, and stored in a cool place.

Such papier maché may be used instead of modeling wax. Take, for this purpose, a piece of the mass; press it out flat in the size needed for the bas relief, coat one side with flour paste and press it on any desired support. Take out any superfluous moisture by pressing a folded linen cloth over it. After this, we can lightly engrave the outline of the low or high relief, with an embossing tool, raising the flattened high spots by fresh applications of maché. This possesses various advantages as compared with modeling wax.

The embossing tool works more easily in the soft dough than in wax. If part or all of the mass should begin to dry it may be gone over with a fine brush dipped in water, and the mass will work as easily as ever.

When the finished bas relief is perfectly dry, it is coated with dilute flour paste with a hair brush, and when this is dry the entire surface is burnished with a bone polishing tool. It is now ready to make impressions from with molding wax. It may also now be coated with thin glue water, again dried and smoothed off in the manner described. This last preparation of the surface fits it for any application of oil or heavy-bodied water colors, or for gilding. After the work has been painted or gilded, it is customary to give it several coats of spirit varnish, and after this is dry, neither heat nor cold, moisture, dust nor fly specks can injure it. The dust can be removed with a soft dusting brush and the fly specks with a moistened rag.—"Verwertung von Abfallstoffen aller Art."

The price of diamonds is tending upward, for some months the importation of the stones having shown a decline, owing to the lessened output from South Africa. This is probably more a market manipulation than a real scarcity.

* Abstracted from Popular Astronomy.