Principle Approach Education

Plotting God's Oceans for Man

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EDITOR'S NOTE: This article offers a curriculum unit for Principle Approach® education which builds the subject in the context of providential history—upon the Biblical principles of education and government, and in the model lesson, identifies Christian scholarship through the life of an individual who contributed to this area of knowledge by his own character. A model lesson and application of the material for the teacher's use is included at the end of the article.

PART I: MATTHEW FONTAINE MAURY

INTRODUCTION

God's ocean is vast, unbounded, and as changeable as the emotions of man. Winds blow across it from all directions, and with all degrees of strength. For thousands of years, the seafarer has been at the mercy of these fickle winds. Like Paul the Apostle, many a seafarer has found himself shipwrecked on some strange shore, the end result of having been tossed about by raging winds and waves [Acts 27]. It is impossible to still the storm, and, it would have seemed, just as impossible to predict it. Yet, at Creation, God commanded man to subdue the earth [Genesis 1:27] and to take dominion over the works of His hands [Psalm 8:6]. In the early 19th century, a man was born, Matthew Fontaine Maury, whose destiny was to find the paths on the vast, unmarked, changing sea. He drew together, to work as one, the seafarers of nineteen nations, according to one plan, for the benefit of all. From this plan, a systematic recording of data, collected over fifty years, resulted in a composite knowledge that brought forth order out of chaos. As a result of this multitudinous study, conducted over many years, the variable winds could be predicted, on the average, according to season, and to geographical location. Based on this new knowledge, "paths"—the best courses for navigators to follow from port to port—could be laid out for each month of the year. No one man, or nation, could have done this work, let alone even conceived of it. God's invisible hand worked through the heart of Matthew Fontaine Maury, through events in America's history, as well as the world's, to bring about the plotting of God's oceans for man.

This article must, therefore, begin with a biographical sketch of Matthew Fontaine Maury, emphasizing the invisible hand of God, moving beneath the events, to bring about His plan for man. However, God's invisible force began hundreds of years prior to Maury's birth. Navigation had to have developed to the point that a ship could precisely determine its position at a given time. In order for this stage to have been reached, practical astronomy had to have progressed to an exact science, because navigation rests upon it. Though Strabo, in the first century, had said, "We must look to the vault of heaven to find our geographical position on earth," it was not until 1627, when Kepler published his planetary and star tables, that mathematicians could calculate fixed geographical positions on earth. Even then, it was not until an accurate timepiece, the chronometer, was invented, that longitude could be determined. To fix the geographical position of a moving ship, a chronometer, a sextant, and a nautical almanac—also called an ephemeris—had to be carried aboard the ship. By 1820, all United States Navy vessels were equipped with these. Still, there were errors in fixing a ship's position, because chronometers were not infalliable, and had to be checked against the only absolute timekeeper—the heavenly bodies. This required the establishment of an astronomical observatory. By the time the United States responded to this need, Maury had been providentially prepared, and was chosen to assume the role of Superintendent of the newly-established National Observatory, later to become the United States Naval Observatory. In summary, we see that God had much to prepare to make all events fit together, in order to bring about His purpose, in His time.

Following the biographical sketch of Maury's life, which will end with nineteen nations cooperating together to monitor the global seas, we will look at the heart of Maury—at his philosophy. As so often happens, more good comes out of an achievement than one could ever have imagined. The plotting of the world's winds and ocean currents resulted in the birth of a new science—Oceanography. We will thus end this article with an introduction into this universal science, which Maury termed, ". . . the most Christianizing of all sciences."

MATTHEW FONTAINE MAURY'S EARLY YEARS

Matthew Fontaine Maury was born in 1806 on a farm outside Fredericksburg, Virginia. Matthew was the seventh child born to Richard and Diana Maury. Matthew was a fourth generation American, named after his greatgrandparents. His great-grandfather was Matthew Maury who had married Mary Anne Fontaine. Two strong Huguenot lines were united in this marriage. The Fontaine's Christian faith dated back to 1535. It can be assumed that Matthew and the other Maury children were repeatedly told inspiring stories of their brave ancestors, who never renounced their faith in the face of persecution, and who many times lost their homes and their livelihood, barely escaping with their lives. The Minor background, Matthew's mother, was Dutch-English. The founder of the Minor line in Virginia had been a Dutch sea captain who renounced the sea for the beauty of Virginia, and became a successful plantation owner in the mid-17th century. Diana's father had fought in the War of Independence, rising to the rank of major.

Even before Matthew was born, it had been evident that the land was not fertile enough to support the large Maury family. In 1810, the Maurys stoically prepared for their rugged 700-mile journey across the Cumberland Gap to the new state of Tennessee. Diana was expecting their ninth child. Three years later, the family was able to purchase its own land, near Franklin. Their house was a large log cabin with a cook house outside. All the boys were expected to help, and their father demanded instant obedience.

His mother taught Matthew to read and to memorize scripture. When he was seven, he was allowed to accompany his older brother, Dick, to school. He learned all of Dick's lessons, as well as his own. His father, always struggling to make a living, valued work on the farm more highly than education. It was only after Matthew was injured by falling from a tree that his father consented to Matthew continuing his high school education at Harpeth Academy. Here he showed great aptitude in both language and mathematics. However, Matthew's father still expected him to become a farmer—a prospect which, he wrote a friend, looked "exceedingly gloomy" to him.

As had been their custom in Virginia, the family carried on their inherited tradition of family worship, morning and evening. They sang the Psalms antiphonally—one part answering another. The Psalms were so well implanted in Matthew's mind that in later years, verses burst forth when he was writing or speaking. Even at play, Matthew's and Dick's knowledge of the Psalms made them more aware of their surroundings—the clouds, the streams and the trees.

Matthew's yearning for an education increased as he began to feel the need to make his life accomplish a purpose. He felt that to be happy, he must benefit others. His brother, John, had joined the United States Navy in order to receive an education, and Matthew decided to do the same. Unfortunately, John had died of yellow fever two years earlier, just before returning to home port. Their father, who had seen John only once during his fourteen years of service, was still deeply grieving. His father was, therefore, adamant against Matthew's following his brother's footsteps. Sadly, Matthew realized, that to carry out his plan, he would have to do so in secret, against his father's will.

Matthew wrote to General Sam Houston, Tennessee's new Congressman, to request a warrant to join the U.S. Navy. Within a month the warrant arrived. A friend lent him a mare, with the understanding that upon reaching his destination, Matthew would sell it and return the proceeds to him. Self-reliant, and unwilling to compromise on his consuming desire for an education, he rode off on the borrowed mare with a few coins a friend had put into his pocket. At nineteen, mind set on his future, he retravelled the same path over the Blue Ridge Mountains his family had taken fifteen years earlier.

A few months later, while eagerly waiting to board the newly-commissioned frigate, *The Brandywine*, he made a vow with himself, "I will make everything bend to my profession." [1] This vow he never forgot. *The Brandywine* was built for the express purpose of carrying America's noble war hero, General Lafayette, back to France. The frigate was named *The Brandywine*, after the battle in which Lafayette had been wounded. It was not by chance that Maury's first assignment placed him on this ship. During the passage, Lafayette took note of this young "middy," and they enjoyed many a conversation together. Maury learned that General Lafayette's motto was "Cur non?" ("Why not?"). Those two words summarized Lafayette's philosophy: "Why not try?—effort was worth the risk of failure—achievement was more to be desired than ease." [2]

While meeting the famous Lafayette was an unanticipated windfall, his promised education in mathematics, astronomy, and navigation never materialized. Although there was a schoolmaster aboard, a regular time for class was not enforced, and so instruction soon fell by the wayside. Disappointed, Maury undertook, by himself, the study of Nathaniel Bowditch's, *The American Practical Navigator*, the official navigation text. Despite the fact that Bowditch was the "bible" from which all naval officers learned the basic principles of navigation, Maury found its exposition unclear, and its use of mathematics limited. Nevertheless, Bowditch was an inspiration to Maury. Soon, he was familiarizing himself with the masters—Euclid, Kepler, Newton and Laplace. Because the solution of basic navigation problems involved depicting spherical triangles on the spherical earth, and on the celestial sphere, Maury found the cannon balls, stowed about the decks, a handy chalkboard! As he paced back and forth on the deck during his watch, he computed the answers to these problems. What he taught himself, he shared with his fellow midshipmen. In addition, his keen mind picked up any strange word or phrase that he heard spoken. He fixed these words in his memory, to be looked up later in a dictionary when he went below, or to be reflected upon while standing watch.

On going before the Examining Board in March, 1831, Maury did not fare well. His examiners, who were unskilled in mathematics, did not understand his mathematical demonstrations. They were accustomed to answers that were literal recitations of Bowditch's rules, and of his formula for finding longitude at sea by lunar observation. As a consequence of their own ignorance, they rated him 27th out of a class of 40. Because of this low rating, his promotion to lieutenant was held back two years.

On June 11, 1831, Maury received his first assignment with serious responsibility—ailing master on the sloop-of-war, *Falmouth*, ordered from New York for duty off the west coast of South America, accompanied by the vessel, *Volage*. His duties were to act as the ship's navigator, and to oversee the ship's inventory. In preparation for this voyage, and in order to reach their destination, Valparaiso, in the shortest feasible time, he sought information on the winds and currents that the ship would encounter on this passage around Cape Horn, notorious for its severe weather. He was sure there would be sailing directions, because there were so many ships rounding the Horn. But search as he did, there was nothing to be found! The fact was—sailing directions were a matter of oral tradition, passed by word of mouth from one ship captain to another. Undaunted by what didn't exist, he determined that on this voyage he would make careful records of the winds and currents. Then, perhaps, he could write some directions of his own! Maury's careful daily records on this voyage included: the course steered, the distance run, astronomical observations of the ship's latitude and longitude, the direction and speed of the current, the direction of the wind, the state of the weather and the variation of the compass from true north.

Not surprisingly, as the *Falmouth* neared the Horn, westerly winds of gale force were encountered, impeding its progress. Up to this time, sea captains saw no alternative other than to buck these winds. The *Volage* made three attempts to round the Horn, under the island, Diego Ramirez, but was driven back on the first two. It took 38 days for the *Volage* to reach Talcahauno, Chile. In contrast, the *Falmouth*, under Maury's navigation, proceeded far south of the Horn into more favorable winds, and in spite of sailing nearly 900 statute miles out of its way, reached Talcahauno in only 24 days, well ahead of the *Volage*!

While on this voyage, the young midshipman began to incorporate his observations and his novel navigation insights into a scientific paper, "On the Navigation of Cape Horn," which was later published in 1834 in the respected *American Journal of Science and Arts*. Maury advised sailing masters to stay close to the island, Diego Ramirez, when the winds were favorable (from the east). But when the winds were unfavorable (from the west), Maury asserted that a ship should continue south to a latitude of 62.5 degrees, where the winds had less westing in them.

During the next three years, Maury sailed around the world, acting as sailing master of two ships. On July 15, 1834, Maury married Ann Herndon, a distant relative, whom he had first met in Fredericksburg nine years earlier, at which time he had only 2S cents in his pocket. Once again he was penniless because he had shared his income with the widow of his deceased brother, John, and with his brother, Dick. However, after a round of visiting relatives, the couple were delighted to receive word that his paper on Cape Horn had been published. This news spurred him on to finish the textbook he had been writing for midshipmen, based on the scraps of paper he had "squirreled away" on the *Brandywine*. The book included sections on algebra, geometry, logarithms, plane trigonometry, spherics, nautical astronomy and navigation.

On the title page of this book were the words he had learned from Lafayette, "Cur non?" The book was published two years later under the title, *A New Theoretical and Practical Treatise on Navigation*, and was a great success. President Andrew Jackson read the book and felt the author deserved a promotion and reimbursement for the cost of publication, but the Secretary of the Navy withheld the payment, saying the book was its own reward! On June 10, 1836, Maury received his long-awaited promotion to Lieutenant in the United States Navy.

Edgar Allan Poe praised the book, writing in his review of it,

> The spirit of literary improvement has been awakened among the officers of our gallant Navy. We are pleased to see that science is also gaining votaries from its rank. Hitherto, how little have they improved the golden opportunities of knowledge which their distant voyages held forth and how little have they enjoyed the rich banquet which nature spreads for them in every clime they visit! But the time is coming when, imbued with a taste for science and a spirit of research, they will become ardent explorers of the regions in which they sojourn. [3]

How prophetic Poe's words were to be! On September, 1844, Maury's book was authorized as the standard U. S. Navy textbook for midshipmen.

During the ensuing years of enforced shoreleave (the Navy then had more officers than ships), Maury embarked on a campaign of naval reform. Charles Lee Lewis, a professor at the United States Naval Academy, wrote in a biography of Maury entitled, *Matthew Fontaine Maury*,

> The navy was then in a condition of dry rot, and the time was ripe for some courageous person to awaken the country to a realization of the true state of affairs and to point out the reforms that were needed.[4]

Writing under the pseudonym, Henry Bluff, in a Richmond, Virginia paper, Maury addressed waste and inefficiency in building ships, the need to reorganize the Department of the Navy, the need for a naval academy, and the embarassing fact of the United States' lack of hydrographic information—even along its very own shores, the Atlantic Seaboard, and the Gulf of Mexico!

His plea for a naval academy came to a crescendo with these words,

> It takes something more than spars and guns, and walls of wood to constitute a navy. These are only the body—the arms and legs without the thews [muscles] and sinews. It requires the muscle of the brawny seaman, and the spirit of the well-trained officer to impart life and mo-tion to such a body, to give vigor and energy to the whole system.[5]

Maury could not bear to think of his beloved Navy floundering in her course. He single-handedly struck out against her imperfections, urging her to heave ho, and to right her course. He thundered, and others took note—especially fellow officers. Remarkably, the remonstrances of this one individual, whose liberty of conscience forbade his remaining silent, caused the "ship" (the Navy) to begin to respond. Eventually, the Navy Department was reorganized along the lines Maury had suggested. Hydrographic studies were initiated, and the United States Naval Academy was established in 1845. He who had received no education from the Navy, now insured that others would not lack. Maury's desire that his life benefit others was beginning to be fulfilled.

In the fall of 1839, a serious accident befell Maury. He had given up his seat inside an overcrowded coach to another passenger, and was seated outside, with the coachman, when suddenly the coach overturned. He received multiple fractures of the thigh and knee. The doctor diagnosed the fractures correctly, but failed to set the thigh bone properly. He received miserable treatment at a nearby inn. The only bright spot during those weary, painful months was a visit from a cousin, who taught him French. He did not reach home for five months, still needing help with getting out of bed and dressing. Unspoken was the fear that gnawed at Maury and Ann—was his naval career ended?

In 1842 the answer came. In spite of his disability, he was returned to active status and was appointed Superintendent of the Naval Depot of Charts and Instruments. This Depot had had an interesting history. Seventeen years earlier, President John Quincy Adams, himself an amateur astronomer, in his first annual message to Congress on December 6, 1825, had suggested the establishment of a national observatory. He noted that, whereas Europe boasted 130 observatories, America had not one. His request was ignored by Congress. However, in November 1830, a Lieutenant Louis M. Goldsborough submitted to the Secretary of the Navy a plea for the need to improve the accuracy of chronometers. Since 1820, naval vessels had been equipped with chronometers, but these instruments, so essential for accurate navigation, gained or lost time, in response to variations in temperature, weather, and various other influences. At sea, chronometer errors caused the determination of the ship's longitude to be in error. For example, an error of one minute of time translates into an error of 15 minutes of longitude, or 15 nautical miles at the earth's equator. Once a chronometer was Set, it was never changed. It was imperative, Goldsborough wrote, that each chronometer be rated as to its accuracy, in order that navigators, subsequently using it, could take its rate of error into account, thereby enabling them to more accurately determine their position at sea. In order to accomplish this, chronometers had to be checked against the only invariable timepiece—the heavenly one. The sun and the stars, the moon and the planets, keep perfect time. Thus, a Depot must be much more than a storage depository for instruments. It must also be an astronomical observatory.

In late 1830, Lieutenant Goldsborough was authorized to collect from various locations where they were stored, instruments belonging to the Navy, not in current use. These included chronometers, sextants, quadrants, theodolites, circles, and meteorological instruments, such as barometers and thermometers. The instruments were to be brought to the Depot, at that time, a rented room in northwest Washington, D.C. Adjacent to the Depot, he built a circular building to house a transit instrument. The transit was mounted on a 20-foot base, sunk into the ground. A transit is a telescope equipped with only one axis of rotation. The sighting axis of the telescope is adjusted to be precisely perpendicular to this axis of rotation. The rotation axis is aligned to be horizontal, as well as oriented east-west. The transit is thus restricted to point only along the local meridian, the north-south-oriented great circle on the celestial sphere that passes through the local zenith. [Ref. *An American Dictionary of the English Language* by Noah Webster (1828), Foundation for American Christian Education: San Francisco (1967)] An observer, looking through the transit, would see the star, and also a fine line in the eyepiece that corresponded to the meridian. The instant the star crossed (transited) the fine line, corresponded to the precise local astronomical time. By comparing this highly accurate time measurement with the time read from a particular chronometer, that chronometer could be "rated." Later, in 1833, the Depot was moved to the home of Lieutenant Charles Wilkes, who succeeded Goldsborough. After Lieutenant Maury's appointment on July 12, 1842, the Depot was again moved to another rented room on Pennsylvania Avenue.

Congress, in its final session of 1842, at last acted on John Quincy Adams' long-standing request. They appropriated $25,000 for the observatory that Adams had requested so long ago. This National Observatory would, of course, include the Depot. The site would be Peter's Hill in Washington, D.C. Robert Peter, at the time of George Washington's presidency, had granted this land to be used by the United States, forever. This site had been chosen by President Washington for a national university, ". . . where the youth of our country may be able to free themselves from local prejudices and jealousies pregnant of mischievous consequences to our country." [6] The university had never been built, because God had reserved this land for this observatory, at this time.

Two years later, another providential event occurred. On October 1, 1844, the Secretary of the Navy, John Y. Mason, appointed Maury to head this new observatory! Secretary Mason reasoned that, although Maury was not an astronomer, his textbook certainly proved his ability in this field. Besides, Maury had performed excellent work at the Depot, including contributions in the field of astronomy. Maury's time had come! The events in Maury's life and the work that he had done, had prepared him for this position. No one nation alone could do the task God wanted accomplished. It would take a concerted effort by the Christianized world. Time was short, for sailing vessels would rule the seas for only a little longer. In less than two decades Maury was destined to overturn the old ways of navigation. Man would then take dominion over the sea!

LIEUTENANT M. F. MAURY: SUPERINTENDENT OF THE NATIONAL OBSERVATORY

In 1844 the new observatory was completed, and at last the Depot had found a permanent home. Initially called the National Observatory, it was later to become the United States Naval Observatory. Thus, Maury is recognized as its first Superintendent. Its primary purpose was to engage in scientific research in the fields of astronomy, hydrography, the earth's magnetism, and meteorology, as well as practical applications in these fields. This work, of course, was designed to the specific needs of the U.S. Navy, but of far greater importance, it was destined to make far-reaching contributions to science, and thereby, to benefit all nations.

The National Observatory was a two-story structure, topped by an impressive 23-foot diameter observatory dome that enclosed a 9.6-inch refracting telescope, called the Equatorial. In addition to offices, the three wings each housed an instrument: the Prime Vertical; the Transit in the south wing; the West Transit in the west wing; and the Meridian Circle in the east wing. Most of these instruments, the work of some of Europe's finest craftsmen, had been carefully selected by James M. Gillis, and represented a considerable investment by the government. On his arrival, Maury found that all the instruments had been installed improperly. His first task was to dismount all of them, repair those that had been damaged, modify the mounting piers, and finally, to remount, and then to realign them. Maury found himself in charge of a staff comprised of junior Naval officers, Navy professors, and a few civilians. He enthusiastically began training the junior officers, so that they could operate the scientific instruments for making the routine observations. He, himself, became the principal user of the Equatorial. An unexpected benefit was that the long hours standing at the telescope were strengthening his leg. In an address to the members of the Virginia Historical Society on December 14, 1848, Maury described his ecstasy at witnessing the precision of the Universe as he observed a star crossing the fine wire in a transit instrument:

> To me the simple passage through the transit instrument of a star across the meridian is the height of astronomical sublimity. At the dead hour of the night, when the world is hushed in sleep and all is still; when there is not a sound to be heard save the dead beat escapement of the clock, counting with hollow voice the footsteps of time in his ceaseless round, I turn to the Ephemeris and find there, by calculation made years ago, that when that clock tells a certain hour, a star which I never saw will be in the field of the telescope for a moment, flit through, and then disappear. The instrument is set;—I look; the star, mute with eloquence that gathers sublimity from the silence of the night, comes smiling and dancing into the field, and at the instant predicted even to the fraction of a second it makes its transit and is gone! With emotions too deep for the organs of speech, the heart swells out with unutterable anthems; we then see that there is harmony in the heavens above; and though we cannot hear, we feel the "music of the spheres." [7]

After a year at the National Observatory, Maury's unbounded enthusiasm conceived of a plan, ". . . to make a contribution to Astronomy worthy of the nation and the age . . ." This ambitious plan was, ". . . regularly and systematically to penetrate, with our excellent Telescope, every point of space in the visible heavens, with the view of assigning position and magnitude [degree of brightness], and of cataloguing every star, cluster, nebula or object that should pass through the field of view." [8]

By 1847 a catalog of 1,200 stars, most of them unknown to existing catalogs, had been published. The National Observatory had gained recognition within the international scientific community equal to that of the best established observatories in the Old World—a stupendous feat in only two years! Though Maury did not succeed in penetrating every point in the dome of the heavens, still he made a "contribution worthy of the nation and the age."

SUPERINTENDENT OF THE DEPOT OF CHARTS AND INSTRUMENTS

Having briefly summarized Maury's astronomical activities, we now turn to what was to be his major contribution. To do this, we must go back to the time of his appointment as Superintendent of the Depot of Charts and Instruments, two years before the completion of the National Observatory. The Depot was at this time located in a rented room on Pennsylvania Avenue. Deposited in a corner was a pile of logbooks. For Maury nothing was so unimportant that it should be overlooked—even an old, dusty logbook! Curious, he picked one up from the heap, and started to leaf through its pages. As he slowly read the handwritten daily entries of the ship's captain—on a voyage now long forgotten Maury began to realize that while most of what had been recorded was of little interest, here and there were to be found entries relating to the winds, weather, sea state, currents, etc.—just the kind of data that he had so diligently sought, way back in the days when he was first assigned to navigate the *Falmouth*!

It was standard practice for the commanders of all Navy ships, upon returning stateside after each passage, to turn in their logbooks, which were then forwarded for storage. For fifty years these logbooks had been accumulating unread by anyone! Eventually, they had ended up here on the floor of this rented room, the temporary Depot. Here, the knowledge gained from every ocean voyage of a U.S. Navy ship was providentially preserved—awaiting discovery! Each log was an account of a particular passage, made at a particular time of the year. As was common practice, each included a daily record of the ship's position, the winds and weather conditions encountered, and the compass variation.

Maury realized that he had stumbled upon, what was for him, a literal gold mine! Up to this time, written directions that a ship's captain could refer to for planning and navigating a particular ocean passage were still nonexistent. In fact, no one, with the exception of Maury, had even a perception of the value that such a prescribed set of sailing directions would have for the timely and safe conduct of a particular ocean voyage. Maury, who throughout his duties at sea had realized this need, lacked a source of the necessary data. Until this moment, he had not realized that such a source of data existed. Of course, it would take an incredible amount of painstaking, persevering work, first to extract, and then to organize the bits and pieces of information contained in the logs into a form where it could be studied. For a particular passage, for example, from England to Australia, Maury knew from his navigation experience, that a ship would encounter winds and ocean currents whose direction and speed would significantly determine the time for passage, depending upon the course the captain chose. If these winds and current patterns were known ahead of time, he realized that it would be possible to chart a course that would take advantage of Nature. Maury at this early stage, before the data from a single logbook had been compiled, had only a vague idea about how to accomplish the goal he had set, but he did know what the first step was to quarry the gold.

Maury proceeded to methodically group the logbooks according to the starting port and the destination of the ship. Then he divided the oceans into "squares," each one 5 degrees of latitude by 5 degrees of longitude (later enlarged to 15 degrees square). This he referred to as "reticulation;" i.e., constructing an imaginary "net" over the oceans of the globe. On these squares he could plot the track of a ship, using the ship's daily position, as recorded in the logbook. The passage from New York to Rio de Janeiro was the most travelled. As he analyzed these tracks, he could now clearly see that the ships were more frequently than not, fighting nature—instead of benefitting from it. The records showed that they tended to buck the prevailing winds and currents, instead of taking advantage of them. As he continued in his research he discovered that winds varied in direction and strength according to season. It was therefore necessary to further divide the same passage into seasons.

Maury envisioned a new type of navigational chart. This chart of a particular area of interest would be overlaid with a grid of squares, corresponding to those used to analyze the data from the logbooks. Within each square would be entered, for each season, the average ocean currents, the average direction and speed of the wind, and the type of weather to be expected. On the chart could be drawn the course or path that a vessel should follow in order to complete its passage in the shortest time, and safest manner.

As Maury continued to dig for the gold in the logbooks, it reminded him of his experiences working in a gold mine near Fredericksburg, when he was first married. He noted the similarity between the two types of "quarrying."

> Maury compared his work in the "quarry of log books" to that of a sculptor, the single touch of whose chisel does but little; but finally like the completed piece of statuary the charts speak for themselves and stand out before the compiler "eloquent with facts which the philosopher had never dreamed were lurking near." [9]

Maury found that the words of Psalm 8, which he knew by heart, often came to his mind. "Thou madest him to have dominion over the works of Thy hands . . . and whatsoever passeth through the paths of the sea." This Psalm confirmed for him the idea that God had, indeed, laid down paths on the trackless sea, along which man could sail. To discover these paths was a part of God's plan for man. During many months of laboriously "quarrying," Maury developed a systematic method which would be useful, both for collecting data, and for collating it. This method would use a standard form, which he called a Blank Abstract, for the purpose of systematically recording the specific types of data he had determined were needed, in place of the arbitrary, often haphazard, logbook entries. The Blank Abstract was scientific, and it was also practical, limiting the requested data to what could readily be collected with the standard instruments carried by most vessels. It would provide a record of the physical conditions at the ocean's surface, as gathered by each ship, along the particular passage it was sailing. Maury's problem now was to persuade ship captains to cooperate in adopting and compiling his Blank Abstract data logs. An important step in this direction was the issuance in late 1842, by the Navy Bureau of Ordinance and Hydrography, of a circular requiring Navy vessels to collect these data and to forward them to Maury at the Depot.

In 1847 he published his first charts, a series of eight, entitled "Wind and Current Charts," covering the Atlantic. Each chart depicted a different type of information; for example, trade winds, storm and rain, whales—all of interest to mariners. He also started a publication, *Explanations and Sailing Directions to Accompany the Wind and Current Charts*, which incorporated his advice to navigators on what was the most advantageous course to follow for a particular passage, as well as other useful information. Maury now foresaw the possibility of mapping the winds and currents of three oceans—the Atlantic, Pacific, and Indian. In the same way that he had desired to chart the entire heavens, he now hoped to take dominion over the world's three open oceans! His reason was likewise the same—that "America could make a contribution," this time to navigation, rather than to astronomy. To accomplish this purpose he needed the records of thousands and thousands of ships. His immense plan was to compile and to present on charts, the prevailing conditions for each 15-degree square of ocean, for all seasons! Maury envisioned data continually flowing into the Depot from ship captains, and a return flow to the captains in the form of revised charts reflecting the newly-gained information. Thus, the science of navigation would be a continuing process, always improving, always getting nearer to God's perfect plan. His vision, however, was not shared by the old salts, even though they, in the long run, would benefit—in return for their cooperation. Ship captains argued that they had grown up on a ship, as had their fathers, and their father's fathers before them. What could anyone tell them about seamanship that they hadn't already learned from experience?

In the same manner that Congress had turned a deaf ear to John Quincy Adams' proposed observatory in 182S, so now the Navy and the Merchant Marine were unresponsive to his need for completed Blank Abstracts. Maury's strongest ally throughout these frustrating years was John Quincy Adams. Maury kept him informed of his activities. In a letter to Adams, Maury explained how he visualized the winds on his charts. He wrote that he depicted their strength and their direction with symbols that looked like paint brushes without handles. The head of the brush pointed in the direction from which the wind blew, and the hairs of the brush could be drawn in such a way as to depict the strength of the winds. As data accumulated, he conceived of another method to better represent the varying winds. He drew a compass circle in each of the 5-degree squares. Each compass circle was divided into 16 sectors, corresponding to 16 points of the compass. The number of times the wind had been recorded as blowing from a particular direction was recorded on that sector. At first Maury used twelve such compass circles, one for each month of the year. He later combined the twelve months into a single compass circle by dividing each sector into four concentric circles, one for each season. Within the segment between consecutive circles, each of the three months of that season were assigned a place. The number of times wind had been observed from a particular heading was recorded in the corresponding compass sector, and at the location designated for the particular season and month. These wind charts were called Pilot Charts, and even today, they are still in use in this same form. At the top of all pilot charts issued by the Navy Hydrographic Office are written these words: "Founded upon the researches made in the early part of the nineteenth century by Matthew Fontaine Maury while serving as a lieutenant in the U.S. Navy." [10]

Navigation, as defined by Nathaniel Bowditch in the *American Practical Navigator*, ". . . is the science which affords the knowledge necessary to conduct a vessel from point to point on the earth's surface, and to enable the mariner to determine, with sufficient degree of accuracy, the position of his vessel at any time." Navigation depends upon accurate position finding, but is much more. Navigation is the whole passage of a ship from beginning to end. Navigation begins with planning one's course, then maintaining that course in all kinds of weather. Psalm 107 describes what it is like to do business in great waters in the midst of a storm. Though navigation by mid-19th century had progressed to the point that a ship's latitude and longitude could be accurately defined, the actual route taken was still a matter of guesswork, and as Maury, himself, had found, often resulted in detours. Navigation could not become a science until the wind, the force that propelled the ship, and the ocean currents in which it sailed, were mapped. Perhaps Maury sensed that the opportunity to find the global winds was short. Only sails could sense from what direction the wind came, and could measure the wind's strength by how they were configured and reefed. Would steam replace sails before his work was completed? His need for cooperation was great. Time was urgent!

Maury's study of the route between New York and Rio de Janeiro from the old logbooks had produced radical sailing directions which he termed, "Fair Way to Rio." This route took advantage of what Portuguese sailors, sailing under the direction of Henry the Navigator in the early 15th Century, had termed the "figure-eight pattern." This figure-eight pattern corresponds to what are now known to be huge gyres (large-scale circulating ocean currents) that are driven by the trade winds, and circulate between the land boundaries of the continents. Gyres circulate clockwise in the northern hemisphere, and counter-clockwise in the southern hemisphere, separated from each other by the waters in the region of the equator. Maury's sailing directions directed ships out of New York to sail directly east, riding the Gulf Stream, until they began to approach the longitude of the Cape Verde Islands—then to head south to these islands and cross the equator west of them. Continue to bear west after crossing the equator to take advantage of the counter-clockwise gyre in the southern hemisphere, then to hug the coastline of Brazil. These unheard-of instructions, which obviously directed a ship far out of its way, were scorned as foolhardy. Who would ever attempt such a ridiculous passage?

There was one brave soul who made his livelihood transporting flour to Brazil and returning with coffee. A still, small voice must have spoken to him, "Try it!" Captain Jackson, commanding the bark *W.H.D.C. Wright* out of Baltimore, decided to take the risk and test these directions. To his amazement, he found himself in Rio seventeen days ahead of time, and returned to Baltimore from Rio eighteen days ahead of time! Altogether, he had saved a total of thirty five days! His passage was undeniable proof that Maury's directions worked! The news of Jackson's passage travelled up and down the Atlantic Seaboard. Suddenly, Maury's Winds and Current Charts were in demand! However, it was soon found out that they couldn't be purchased! The price for these charts was not money, but cooperation. In order to obtain them free of charge, ship captains had to request copies of Maury's Blank Abstracts, now called

Abstract Logs, and promise to fill them in during their voyage, and then to forward them to the Naval Depot upon the ship's return.

By 1851 Maury could report that 1,000 American vessels were reporting to him at the Depot, now known as the National Observatory! He wrote:

> . . . enough material had been collected from abstract logs to make two hundred large manuscript volumes each averaging from two thousand to three thousand days' observations. [11]

Often letters accompanied the Abstract Logs that were sent to the National Observatory, praising Maury for the work he was doing. The tedious duty of standing watch was now elevated to that of a scientist. As Poe had predicted, seamen were now enjoying and recording the "rich banquet of nature spread before them in every clime." A fellow co-laborer, as Maury called the sea captains, wrote:

> Such as it is, I am happy to contribute my mite towards furnishing you with material to work out still farther towards perfection your great and glorious task, not only of pointing out the most speedy route for ships to follow over the ocean, but also teaching us sailors to look about us and recognize the wonderful manifestations of the wisdom and goodness of the great God—for myself I am free to confess that for (the) many years I commanded a ship—I yet feel that until I took up your work I had been traversing the ocean blindfold. [12]

Maury's reticulation of the oceans in 1S-degree squares caught in its web a vast amount of data. He produced charts depicting the ocean temperature, meteorological information on precipitation and storms, and other marine phenomena. The observation of whales provided information on their migrations and breeding habits—and an unexpected discovery. A whale with a harpoon in it was sighted in the Bering Straits. The harpoon was dated, and carried the ship's name. A check of the records of that ship showed that its location had been in Baffin Bay on the particular date that this whale had been harpooned. The whale had thus gone from the Atlantic to the Pacific Ocean by way of an existing, but still unknown passage—the long-sought-for Northwest Passage!

Still another unexpected benefit that resulted from plotting God's oceans was the laying down of directional shipping lanes—"paths" for steamers to stay in, in order to avoid collision with a ship travelling in the opposite direction. Collisions in the North Atlantic had been frequent because of fog.

> Maury's proposal was published in New York in 1855 by the Board of Underwriters and was entitled *Lanes for the Steamers Crossing the Atlantic*. The booklet explained that the lanes were laid out to keep ships away from icebergs and fogs, in so far "as possible, as well as to avoid collisions. Maury had determined the position of the lanes by studying logs of 46,000 days of observation of winds, currents, and weather in the part of the North Atlantic through which the ships would travel. Two lanes were laid down, each 20 to 25 miles wide. Maury proposed that ships bound from Europe to the United States should

> use the northernmost lane and east bound steamers should travel a lane from one to ten degrees to the south. Because of meteorological and other factors, the lanes were different for summer and winter. [13]

Maury's North Atlantic Chart proved itself useful in an unforeseen way. On Christmas Eve, 1853, the ship *San Francisco* was disabled in a hurricane. The *San Francisco* was sighted by another ship, which returned the 300 miles to New York to get help. Maury was called upon to locate the position that the damaged ship would have drifted during the elapsed time before a rescue ship could reach her. Maury calculated where the *San Francisco* would have drifted, and two cutters were dispatched. They found the ship where Maury had said she would be. The sailing days of "b' guess and b' God" were over! Navigation had become a precise science!

In a speech to the American Association for the Advancement of Science on September 22, 1847, Maury gave a full report on his Wind and Current Charts. They were so impressed with the universality of his thinking that they wondered if other nations of Christendom might be induced to cooperate? They wrote a resolution to this effect, but nothing came of it. It was not yet God's time. In 1851 a request came from Britain's Royal Engineers suggesting that America cooperate with Britain in making land meteorological observations. Eventually the request was handed to Maury to formulate a response. Maury clearly saw that if America were to adopt Britain's system, designed for land observations, it would likely disrupt the collection system already in place in the United States, thereby jeopardizing America's research in this field. He wrote the Royal Engineers, pointing out that the better part of the earth is ocean, and as a consequence:

> . . . we must look to the sea for the rule, to the land for the exceptions. Therefore, no general system of meteorological observations can be considered complete unless it embrace the sea as well as the land. [14]

Having laid down the guiding principle of oceanography, he proceeded to turn the British proposal completely around by saying that the National Observatory's work at sea would be greatly helped by being augmented by land observations. He described Russia's strong commitment to gathering meteorological data throughout its vast territories, and then suggested an amendment to the British proposal—the establishment of a universal system of meteorological observations for the sea, as well as for the land, to be adopted by England, France, Russia and any other interested nation. Furthermore: "For this reason, I beg leave to suggest a meteorological conference." [15]

Maury's counter proposal was the seed idea for what was to be the first multi-national cooperative scientific effort. When this "amendment to the British proposal," as Maury tactfully called it, was being debated in the House of Lords on April 23, 1853, Lord Wrottesley, an eminent astronomer and scientist, rose and spoke in support of Maury's proposal. He told of the great savings to commerce that accrued as a result of Maury's research. Since shipping costs are compounded by the number of days at sea, shortening the passage effected great savings. He ended his speech by reading the following report of the Royal Society:

> Short as is the time that this system has been in operation, the results to which it has led have proved of very great importance to the interests of navigation and commerce. The routes to many of the most frequented ports in different parts of the globe have been materially shortened—that to St. Francisco in California by nearly one-third; a system of southwardly monsoons in the equatorial regions of the Atlantic and on the west coast of America has been discovered; a vibratory motion of the trade-wind zones, and with their belts of calms and their limits for every month of the year, has been determined: the course, bifurcations, limits, and other phenomena of the great gulf stream have been more accurately defined; and the existence of almost equally remarkable systems of currents in the Indian Ocean, on the coast of China, and on the Northwestern coast of America and elsewhere, has been ascertained. There are, in fact, very few departments of the science of meteorology and hydrography which have not received very valuable additions . . . Lieutenant Maury is enthusiastic in the cause; he sees the benefits that must arise from the extension of this system of observations, and he invites the co-operation of all maritime nations; but to which does he look with the most longing eyes and the best hopes of success? . . . it is to the Government of this country that the demand for co-operation, and for the interchange of observations, is most earnestly addressed by the Government of the United States. [15]

The facts were that Maury's proposed globe-circling route to Australia and to New Zealand had saved Britain 1,300 pounds per 1,000-ton ship, annually. Similarly, for the passage to India, Her Majesty's ships had, it was estimated, been saved the equivalent of $1,000,000 to $2,000,000 each year. The total yearly savings to British commerce was estimated to be $10,000,000.

On August 23, 1853, the first International Maritime Meteorological Conference was held in Brussels. (This organization subsequently changed its name to the World Meterological Organization.) Delegates from ten countries were represented: Belgium, France, Great Britain, The Netherlands, Norway, Portugal, Russia, Sweden and the United States. All delegates were naval officers except Belgium's, who was a scientist named Lambert Adolphe Jacques Quetelet. Quetelet, who was elected presiding officer, asked Maury to give the opening address, stating the aims of the conference. Maury spoke in simple French, which he had learned in the miserable inn where he lay after his accident.

Maury was then asked to explain his Abstract Logs, and his prescribed method for recording the information. He told the delegates that he had been authorized by his government to offer to interested maritime nations his charts on the same basis that they were being offered to United States ships. That basis was simple—cooperation. The various nations were to send their completed Abstract Logs to the United States National Observatory in order that this information could be used to improve the accuracy of future charts.

After two weeks of debate a vote was taken. It was unanimously in favor of the universal system the delegates had worked out together. Provision was made for countries not in attendance to join at a later time. Prussia, Spain, Portugal, City of Hamburg, the Republics of Bremen, Chile, and the Empire of Brazil, all later joined. Eventually, the nations participating in this venture of international cooperation represented nine-tenths of the shipping interests of the world!

"Freely ye have received, freely give," [Matthew 10:8]. Matthew's generous spirit, evident throughout his life, had united nineteen nations of the world to work together to discover the secret paths of God's oceans. His goal was not the benefit of anyone nation or age, but the benefit of all. To contribute to his plan was to receive. Every ship was a floating observatory, as Maury wrote:

> Rarely before, has there been such a sublime spectacle presented to the scientific world: all nations agreeing to unite and cooperate in carrying out one system of philosophical research with regard to the sea. Though they may be enemies in all else, here they are to be friends. Every ship that navigates the high seas, with these charts and blank abstract logs on board, may henceforth be regarded as a floating observatory, a temple of science. [16]

On January 29, 1855, Senator S. R. Mallory of Florida gave a long speech to the Senate Naval Affairs Committee commending Maury's work. He reported that the Abstract Logs submitted to the Observatory, ". . . already fill nearly four hundred large manuscript volumes." [17]

> In the fifty years subsequent to the Brussels Conference, Dutch seamen turned in three and a half million of the prescribed abstract logs accurately filled out, American seamen five and a half million, British seamen seven million, and German seamen more than ten and a half million.[18]

As we look at a globe, or at ocean maps, we see small blue and small red arrows. These arrows represent the warm (red) currents and cool (blue) currents discovered by the ocean temperature measurements made by these floating observatories as they sailed over all the oceans. Like pelican wings stretched out to capture the upward draft from the ocean surface, so sails also sensed the winds from every quarter. This was the peak of the sailing age. Sleek clipper ships, designed in 1845, raced each other on voyages around the world, all the time carefully recording the data which, in the future, would make their passages even faster. Yet time was short. As soon as their scientific work was finished, these floating observatories would be replaced by steamships. Now the "observatories" are sensors adrift on the sea monitored by satellites in space the world over. Though ocean research in the last two decades has become incredibly sophisticated and detailed, the research founded upon Mat-thew Fontaine Maury's work is regarded as "very solid." It established the correct base picture.

Maury had made the whole world kin; his love of God had inspired nations to see his vision for safer, shorter passages on the oceans of the world. For a brief time they had set aside the need for war. Seamen of the world were all colaborers working for their own, as well as for one another's good. "Freely ye have received, freely give."

THE PHILOSOPHY OF MATTHEW FONTAINE MAURY

"Freely ye have received, freely give," [Matthew 10:8]. Out of the abundance of his heart, Maury gave to others. The more that Maury studied and learned, the more he had to give. Knowledge led to a deeper and deeper understanding of God's love and wisdom. Knowledge was the spring of life from which Maury felt privileged to drink. The joy of discovery burst forth in Maury uncontrolled. As he had received, he had no choice but to give. He shared with his fellow midshipmen, he shared with his children, he shared with his countrymen, and he shared with the world. Drink from the well of living water, and you will never thirst, but, instead, will have joy bubbling up unbounded and free.

Maury saw no contradiction between the Bible and science. The Author of the Bible and the Creator of the universe were one and the same. When Maury shared his findings of physical geography, he simultaneously shared the Bible. His book, *Physical Geography of the Sea*, published in 1855, which went through five printings the first year in America, and a total of nineteen in England, was a book of praise .

> . . . The Bible frequently makes allusions to the laws of nature, their operation and effects. But such allusions are often so wrapped in the folds of the peculiar and graceful drapery with which its language is occasionally clothed, that the meaning, though peeping out from its thin covering all the while, yet lies in some sense concealed, until the lights and revelations of science are thrown upon it; then it bursts out and strikes us with exquisite force and beauty. As our knowledge of nature and her laws has increased, so has our understanding of many passages in the Bible improved.[19]

In a speech in Sewanee, Tennessee in 1860, Maury defended his steadfast faith in the harmony between the Bible and his scientific researches:

> I have been blamed by men of science, both in this country and in England, for quoting the Bible in confirmation of the doctrines of physical geography. The Bible, they say, was not written for scientific purposes, and is therefore of no authority in matters of science. I beg pardon! The Bible *is* authority for everything it touches. What would you think of the historian who should refuse to consult the historical records of the Bible, because the Bible was not written for the purposes of history? The Bible is true and science is true.[20]

Maury compared learning to the difficult task of climbing a mountain. One was rewarded along the way, as distant peaks (new understanding) slowly emerged. The summit, however, left the climber breathless and humbled.

> But as we study the laws of nature . . . It is like climbing a mountain; every fact or fresh discovery is a step upward with an enlargement of view, until the unknown and the mysterious become boundless—self infinitely small; and then the conviction comes upon us with a mighty force, that we know nothing—that human knowledge is only a longing desire.[21]

In the same speech that he compared learning to mountain climbing, he urged the young to exert themselves and study. This advice was no idle talk, but he was passing along to them his own experience.

> There are some here who though not seamen are nevertheless about to become masters of their own acts, and who are about to try the voyage of life upon a troubled sea. I have been some little time on that voyage; and it is so that, whenever I see a young man relying upon his own resources and setting our alone upon his long voyage, my heart warms towards him. I always desire to range up along side of him, to speak to him kindly, and whisper words of encouragement in his ear.
>
> . . . One was never to let the mind be idle for the want of useful occupation, but always to have in reserve subjects of thought for the leisure moments and the quiet hours of the night. When you read a book, let it be with the view to special information.[22]

Maury entered science with an all encompassing, all embracing premise; namely, that the earth had a purpose. The purpose of the earth was that it was made for man. "The heaven, even the heavens, are the Lord's: but the earth hath he given to the children of men." [Psalm 115:16] "He hath established it, He created it not in vain, He formed it to be inhabited." [Isaiah 45:18]

> Upon no other theory can it be studied; upon no other theory can its phenomena be reconciled . . .
>
> Physical geography makes the whole world kin. Of all the departments in the domains of physical science, it is the most Christianizing. Astronomy is grand and sublime; but astronomy overpowers with its infinities, overwhelms with its immensities. Physical geography charms with its wonder, and delights with the benignity of its economy. Astronomy ignores the existence of man; physical geography confesses that existence, and is based on the Biblical doctrine that the earth was made for man.[23]

Maury referred to God as the Great Architect. The Great Architect designed the earth so that all of its parts—the land, the sea, the air—with all of its sub parts, all fit together into a magnificent harmony. Out of all the diversity of parts and sub parts, comes unity, because all things, in the beginning existed in the mind of the Creator, the Great Architect.

> As a student of physical geography, I regard the earth, sea, air, and water, as parts of a machine, pieces of mechanism not made with hands, but to which nevertheless certain offices have been assigned in the terrestrial economy. It is good and profitable to seek to find out these offices, and point them out to our fellows; and when, after patient research, I am led to the discovery of any of them, I feel with the astronomer of old as though I had "thought one of God's thoughts"—and tremble.[24]

Maury was a frugal man. He learned the necessity of thrift as he grew up, and practiced it during the lean periods of his life when he was inadequately compensated for his work. It is not surprising that he used the term "terrestrial economy" in referring to the earth. He saw that the terrestrial economy operated in a frugal manner, where nothing was wasted, and, indeed, many effects resulted from one cause. Every created work responsibly fulfilled its office, and nothing was too little to be unimportant. The land, sea and air were in balance according to the various offices each performed. The forces that controlled the operation of the terrestrial economy were called agents. The terrestrial economy was so efficient that Maury likened it to a machine.

> To one who has never studied the mechanism of a watch, its main-spring or the balance-wheel is a mere piece of metal. He may have looked at the face of the watch, and, while he admires the motion of its hands, and the time it keeps, or the tune it plays, he may have wondered in idle amazement as to the character of the machinery which is concealed within. Take it to pieces, and show him each part separately; he will recognize neither design, nor adaptation, nor relation between them; but put them together, set them to work, or point out the offices of each spring, wheel, and cog, explain their movements, and then show him the result; now he perceives that it is all *one* design; that, notwithstanding the number of parts, their diverse forms and various offices, and the agents concerned, the whole piece is of *one* thought, the expression of *one* idea. He now rightly concludes that when the main-spring was fashioned and tempered, its relation to all the other parts must have been considered; that the cogs on this wheel are cut and regulated—*adapted*—to the rachets on that, &c.; and his final conclusion will be, that such a piece of mechanism could not have been produced by chance; for the adaptation of the parts is such as to show it to be according to design, and obedient to the will of *one* intelligence. So, too, when one looks out upon the face of this beautiful world, he may admire its lovely scenery, but his admiration can never grow into adoration until he will take the trouble to look behind and study, in some of its details at least, the exquisite system of machinery by which such beautiful results are brought about. To him who does this, the sea, with its physical geography, becomes as the mainspring of a watch; its waters, and its currents, and its salts, and its inhabitants, with their adaptations, as balance-wheels, cogs, and pinions, and jewels in the terrestrial mechanism. Thus he perceives that they too are according to design—parts of the physical machinery that are the expression of One Thought, a unity with harmonies which One Intelligence, and One Intelligence alone, could utter.[25]

Maury's faith in God the Creator was, at the same time, a personal faith in Jesus Christ, to whom he was accountable. The prayer which he composed and said every night subsequent to his accident indicates his dependence upon Jesus.

> Lord Jesus, thou Son of God and Redeemer of the world, have mercy upon me!
>
> Pardon my offences, and teach me the error of my ways; give me a new heart and a right mind.
>
> Teach me and all mine to do thy will, and in all things to keep thy law. Teach me also to ask those things necessary for eternal life.

> Lord, pardon me for all my sins, for Thine is The Kingdom and the power and the glory, for ever and ever, Amen.[26]

Maury saw the earth as one, a unified whole, created by One Intelligence, for one purpose. Is it any wonder that he could make the whole world kin, and mobilize the seafaring nations of the world to monitor the world's oceans? Matthew Fontaine Maury was a man after God's own heart. He sought what was best for mankind. He gave of himself unsparingly, and praised God's greatness through all of his work. He looked beneath the appearances to the invisible cause or causes. God richly blessed him with wisdom, patience, and joy.

PART II: TEACHING OCEANOGRAPHY

WHY TEACH OCEANOGRAPHY IN CHRISTIAN SCHOOLS?

Matthew Fontaine Maury believed that of all the sciences, physical geography (now called oceanography) was the most Christianizing. What did he mean? Oceanography embraces the whole world simultaneously. It is a global science that not only considers the 72% of the earth's surface that is ocean, but also the remaining 28% that is landmass. It comprehends the wholeness of the world geographically. But it is much more than this, because all of the sciences play their part in this one grand, whole science. It brings together into one, all the sciences, making each, as a consequence, more meaningful in and of itself. "In the beginning God created the heaven and the earth" [Genesis 1:1]. Oceanography looks upon the earth as a body in which all the systems work together for its preservation, as is true of the human body. Our circulatory, respiratory, digestive, muscular, nervous and skeletal systems all work together for our benefit. In like manner, the atmosphere, hydrosphere (ocean) and lithosphere (land), all work together for one purpose—the preservation of life. Wherever one probes, one finds to his amazement how beautifully all the laws of nature and the constituents of the earth work together for good. This science brings one close to the Creator, because the fit of all the parts—major and minor—is such that the creation of the earth was the result of one plan which existed beforehand in the mind of the Creator. Oceanography provides proof of the validity of one magnificent Creator, the Great Architect, as Maury referred to God. The earth is the watch that Maury described.

Definition of Oceanography

Oceanography is the exploration and the scientific study of the ocean and all phenomena related to the ocean, including all the forces that act upon it. It is a science of *interactions* and *interrelationships*—between the oceans and the land masses, between the ocean and the atmosphere, between the earth's crust and the underlying mantle, between layers of the ocean extending to the ocean bottom, and between stretches of the ocean that span all latitudes. Oceanography is concerned with the unique properties of the molecule, water—in its gaseous, liquid and solid states. It is concerned with the composition of seawater, and the resulting physical, chemical, meteorological and biological effects of the ocean. The sun's radiation, the major source of energy that underlies these interactions, the rotation of the earth about its tilted axis, the earth's orbital motion about the sun, all contribute to the generation of ocean currents. The moon, in combination with the sun, produces the familiar tides. Resources abound in the ocean and in the sea floor. Finally, oceanography is concerned with the innumerable life forms in the sea, and their relationship to their ocean habitat.

Definition of Christian Oceanography

Christian oceanography incorporated into the study of oceanography the study of God's government of planet earth, and is therefore an example of government in its most perfect state. This government is characterized by balancing of forces, by cyclical movements, by internal forces in opposition with external forces, by simultaneous interaction between many constituents, by alternating activity and rest, by division of levels, by separation, by diverse operations of one agent, by constancy, by exact measurement both of time and matter, by perfection of design from the greatest to the smallest body and part, by purpose fulfilled in structure and by proportion and geometric design. All agents from the core of the earth to the distant sun exert their influence and contribute to the overall economy of our planet. All constituents, agents, bodies, and forces were made by God, and 'without Him was not anything made that was made.'

Christian oceanography takes dominion over oceanography, and is subject to the philosophy of American Christian Education. In this way oceanography, the government of planet earth, becomes an example for both the government of individuals, and of nations.

Biblical Principles

At the core of oceanography, is God the Creator. God's character is manifest in His works [Romans 1:20]. Therefore, by studying God's works, one is studying God's character. The Biblical principles of oceanography can be derived from the whole content of the subject, or from the Bible. Biblical principles wend their way through the content of the subject. They are therefore repeated and reinforced by a multiplicity of physical examples. Students studying oceanography imbibe these principles that represent, in part, the character of God. The Westminster Catechism states that, "the purpose of man is to glorify God and enjoy Him forever."

My study of oceanography has led to the discovery of five principles. These are: *Purposefulness in Creation*; *Perfection in Creation*; *Unity in Creation*; *Steadfastness in Creation*; and *Internal Control in Creation*. These five principles simplify the study of the immense content of oceanography. They help because these principles have solid Biblical roots which are easily understood, and are amply illustrated throughout the Bible. They also help because throughout history there are people whose lives have exemplified these principles. Thirdly, these principles help because we see the application, or lack of application, of them in our own lives.

Course Goals

1. Science is knowledge of the holy. To teach science is to teach about God the Creator. Knowledge, in and of itself, puffeth up, but love of God edifieth.
2. The earth was made for man, and man, in turn, needs to be grateful for the design of the whole body earth, and to appreciate the details of its design.
3. God gave man dominion over the earth. Man, made in God's image, is to learn to protect that which God saw was good. Stewardship, the preservation of the earth, requires knowledge. Knowledge leads to a long term point of view, saving the earth for posterity.
4. The earth is a perfect example of government. Studying the many properties of earth and their relationships to each other, ought to lead to an interest in government, self-government and civil government.
5. Matthew Fontaine Maury's life provides an outstanding example of how God providentially worked through history, and man providentially looked to God for direction. Placing Matthew Fontaine Maury on the Chain of Christian History is therefore a goal of this course.

TEACHING OCEANOGRAPHY IN CHRISTIAN SCHOOLS

Now that we have defined this vast science, we are left with the overwhelming question of how it can be taught. It needs to have a background prepared, upon which it can rest, because it is such an immense subject. This preparation may begin as early as kindergarten, as children learn about evaporation, condensation, sinking, buoyancy, plants, animals, magnetism, temperature, etc. Later, children can be introduced to states of matter as they study ice, water, and water vapor; snow, rain and fog. Gradually, more difficult physical principles and laws can be added to the growing base of knowledge.

Teachers can pull out terms to be taught according to their degree of difficulty. Preparing the background of oceanography may appear to be an eclectic approach, as each year students may be taught in a number of different sciences. By the time the student reaches 9th grade, most of these scientific terms should be familiar. Since oceanography is a "whole" science, students will be enabled to see the complexity of Creation, because nothing that was done was done separately or independently of the whole. Following a course in oceanography, students can then concentrate on individual sciences such as biology, chemistry and physics, studying them in depth. Oceanography thus provides an overview of science.

Scope of the Study of Oceanography

Following is a listing of scientific terms broken down into the individual sciences which demonstrate the scope of oceanography. Some of these terms are prerequisite to the course. arc, dimension, coordinate system, origin, axis, perpendicular, sphere.

Geometrical Terms: Point, line, plane, triangle, vertex, angle, obtuse angle, acute angle.

Geographical Terms: Shape of the earth, latitude, longitude, meridian, prime meridian, pole, equator, hemisphere, Tropic of Capricorn, Tropic of Cancer, Arctic Circle, magnetic poles, continent, landmass, Arctic, Antarctic, strait, inland sea.

Astronomical Terms: Celestial sphere, celestial pole, celestial equator, right ascension, declination, ecliptic, First Point of Aries, equinox, zenith, nadir, azimuth, elevation, orbit, astronomical unit, inclination, period of revolution, axis of rotation, period of rotation, day, year, sun, moon, planets, solar system, seasons.

Navigational Terms: Compass, compass heading, true north, earth's magnetism, magnetic north, magnetic variation, course, great circle course, dead reckoning, ocean current, celestial navigation, sextant, almanac, ephemeris, chart, log.

Physical Terms: Distance, time, mass, force, centrifugal force, centripetal force, gravity, displacement, buoyancy, density, energy, kinetic energy, potential energy, velocity, acceleration, momentum, angular momentum, temperature, Celsius scale, Fahrenheit scale, Kelvin scale, heat, calorie, states of matter (solid, liquid, gaseous), vapor pressure, evaporation, condensation, sublimation, fluid, incompressibility, compressibility, velocity of sound (in air, water, solids), streamline, vorticity, viscosity, radiation, absorptivity, electrostatic force, electric current, magnetic force, magnetism, electromagnetism, thermodynamics, atom, electron, proton, neutron, nucleus, units.

Chemical Terms: Elements, molecule, chemical symbols, chemical reaction, chemical formula, bond, covalent bond, ionic bond, ion, solution, polarity, saturation, equilibrium, molecular structure, crystal structure, surface tension, diffusion.

Geological Terms: Core, mantle, asthenosphere, crust, lithosphere, convection, sea floor, ocean floor, continental shelf, earthquake, seismology, seismograph, volcanism, crater, lava, lava flow, igneous rock, hot springs, geyser, hydrothermal, deposit, sediment, sedimentary rock, strata, limestone, coral, atoll, ice cap, glaciation, sea ice, iceberg, erosion, weathering, basalt, granite, mountain-building, rift valley.

Meteorological Terms: Atmosphere, atmospheric composition, water vapor, carbon dioxide, aerosols, troposphere, stratosphere, mesosphere, ozone layer, atmospheric pressure, barometer, relative humidity, dew point temperature, insolacion, albedo, atmospheric circulation, condensation, cloud, cloud types, expansion cooling, compression heating, heat capacity, latent heat of evaporation, precipitation, precipitation forms, weather map, diurnal.

Biological Terms: Cell, microbe, algae, plankton, zooplankton, phytoplankton, diatom, coral, chlorophyl, photosynthesis, plant kingdom, animal kingdom.

Reasoning from the Whole to the Parts

Initially, dividing the subject of oceanography into parts was exceedingly difficult because each part was so intertwined with, and interconnected to, other parts. Because of the "wholeness" of the subject, it was also difficult to choose a logical point at which to begin to study it. Recognizing that there are many different approaches that can be followed, I have arbitrarily arrived at a plan that has proven to be effective.

Ten Constituents

My study of oceanography first led to the discovery of Ten Constituents, or parts. If one asks the question, "What affects the ocean?" one realizes that, of course, the sun does. As one continues to ask this question, one continues to find the essential parts, the rudiments upon which the course consists. These essential parts are the Constituents of Oceanography. As the *Sun* is a constituent, so also are the basins in which the oceans lie, as well as the forces within the earth that affect the oceans. This latter constituent is known as the *Physical Earth*. Then, too, the atmosphere that lies above the oceans intereacts with them. Thus the *Atmosphere* also becomes a constituent. The *Ocean*, itself, must be studied by latitude and by depth, as well as by the individuality of the ocean basins. Oceans are made of water and chemical compounds that are dissolved in the waters of the oceans. It is the unique properties of water, and of these chemical substances that make ocean water what it is. *Water* and *Sea Water* are therefore also constituents. The oceans do not lie still, but move, and how they move affects the ocean, itself. The *Circulation of the Oceans* is also an essential part, or constituent. The small satellite that hovers over the earth affects the movement of the earth's watery covering. Thus, the *Moon* is a constituent. The ocean contains life forms of all sizes and descriptions, and these life forms, in turn, affect the ocean. *Life* is another constituent. Then there are invisible factors; for example, gravity, the earth's rotation, its tilt, and its orbital motion around the sun, which profoundly affect the ocean. These factors are entitled *Earth's Properties*, because they are an integral, governing part of the earth, laid down by God when He created the earth.

Making the Course Live

Matthew Fontaine Maury's writings should be interspersed throughout the entire course. *Physical Geography of the Sea* was the first textbook in oceanography, and abounds with Maury's enthusiasm and reasoning. Long before the evidence was collected and analyzed, Maury reasoned out the role of salt in seawater, the roles the ocean currents play in the terrestrial economy, the coupling of two oceans—atmosphere and hydrosphere, the existence of ocean bottom currents, the importance of evaporation and precipitation, atmospheric circulation in each hemisphere and much more. His imagination allowed him to view a particle of air, or a drop of water, or a tiny marine animal feeding upon the microscopic particulates the kindly currents supplied.

The beauty of Maury's writing, combined with Bible verses, gives life, breath, and excitement to this "far off and exceedingly deep" subject [Ecclesiastes 7:24].

[1] Williams, Frances Leigh, *Matthew Fontaine Maury: Scientist of the Sea*. Rutgers University Press: New Brunswick, New Jersey (1963), p. 43.
[2] Williams, p. 109.
[3] Williams, p. 110.
[4] Williams, p. 109. 3 Lewis, Charles Lee, *Matthew Fontaine Maury: The Pathfinder of the Seas*. The United States Naval Institute: Annapolis, Maryland (1927), pp. 34-35.
[5] Lewis, p. 37.
[6] Herman, Jan K., *A Hilltop in Foggy Bottom: Home of the Old Naval Observatory and the Navy Medical Department*. Naval Medical Command, Department of the Navy: Washington, D.C.; Reprinted from *U.S. Navy Medicine*, p. 5.
[7] Lewis, pp. 46-47.
[8] Williams, p. 163.
[9] Lewis, p. 53.
[10] Williams, p. 195.
[11] Lewis, p. 55.
[12] Williams, p. 192.
[13] Williams, p. 266.
[14] Williams, p. 206.
[15] Williams, p. 213.
[16] Lewis, p. 58.
[17] Caskie, jaquelin Amber, *Life and Letters of Matthew Fontaine Maury*. Richmond Press, Inc.: Richmond, Virginia (1928), p. 35.
[18] Williams, p. 221.
[19] Maury, Matthew Fontaine; John Leighly, editor, *The Physical Geography of the Sea*. The Belknap Press of Harvard University Press: Cambridge, Massachusetts (1963), p. 87.
[20] Lewis, pp. 98-99.
[21] Williams, p. 268.
[22] Williams, pp. 267-68.
[23] Lewis, p. 96.
[24] Lewis, pp. 99-100.
[25] Maury, pp. 69-70.
[26] Williams, p. 125.