

oration takes place since the molecules possess no motion of translation, and therefore there is no change in internal energy. Increase the temperature to T at constant volume v'' , which gives rise to an increase in internal energy according to Theorem (A). Thus on passing from the condensed state at the absolute zero of temperature to any other physically possible state the controllable internal energy is increased, and that state therefore corresponds to the zero of this quantity.

Next consider the controllable entropy. Let an adiabatic on a v, T diagram pass through the zero of entropy. Take a point on the curve corresponding to the volume v_0 and temperature T . Now if we pass from this point at constant volume v_0 to the temperature $T=0$ we arrive at the point of zero internal energy. This would evidently correspond to a decrease in entropy. But the entropy can undergo an increase only, and therefore the adiabatic must pass through the point of zero internal energy. This point may therefore also be taken as the zero of the controllable entropy.

Formulae for the controllable internal energy, entropy, free energy and potential, corresponding to any possible state of matter, may now immediately be deduced. They may be used to solve thermodynamical problems, which, as will be evident on reflection, usually involve externally controllable equilibria only. In general it will appear that by the introduction of controllable quantities a new and important aspect is given to the whole subject of thermodynamics. The results given include what is known as the third law of thermodynamics, and Nernst's theorems, besides a number of other important results may be deduced directly from it, which lack of space will not allow to be given here.

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THE WHALE-SHARK, RHINEODON TYPUS, IN THE GULF OF CALIFORNIA

THE first and last records of this giant shark in American waters are from the Gulf of California, but these last printed records are not in scientific publications and hence are lost. Furthermore, there have come to me in letters or by word of mouth four other trustworthy accounts which corroborate the printed narratives. Hence it has seemed of value to bring all this evidence together and make definite record of it.

For the earliest account of a whale shark in the Gulf of California, one must go as far back as 1865. It seems that in the year 1858 a Captain Stone had sent to the Smithsonian Institution the vertebrae and jaws of an enormous shark captured in the waters of Lower California and known therein as the "Tiburon

ballénas" or "whale shark." The data accompanying this material (length, twenty feet, width of head six feet, back covered with reddish spots, head truncated in front, etc.), together with the extraordinary tooth structures, left no doubt that it was the whale shark. These data and material came into the hands of Dr. Theodore N. Gill, and in 1865 he published a brief note entitled "On a New Generic Type of Sharks."¹

Gill of course knew of the discovery of this fish by Dr. Andrew Smith in April, 1828, in Table Bay, Cape of Good Hope² and likewise he had undoubtedly seen Smith's figure published twenty years later. However, misled by Smith's description and Müller and Henle's³ defective figure of the teeth, Gill, while retaining this fish in the family Rhineodontidae, differentiated it from Smith's *Rhineodon typus* and described it under the new name *Micristodus punctatus*—the spotted shark with the small teeth. There is, however, every reason to reduce this name to synonymy and identify this and all other specimens of whale sharks from the Gulf of California as *Rhineodon typus*. The writer has personally examined the teeth of the alleged *Micristodus* and has found them identical with those from a *Rhineodon* taken on the Florida coast. Furthermore, both sets of teeth agree absolutely with Gill's description—"Each tooth is recurved backwards and acutely pointed, swollen and with a heel-like projection in front rising from the base."

In the *Santa Catalina Islander* for May 27, 1925, the well-known novelist and deep sea angler, Zane Grey, has an article entitled "Fishing Virgin Seas." On page 10, he speaks of trying to capture off Cape San Lucas a whale shark estimated at over fifty feet in length. The story of this contest is told in Mr. Grey's characteristic vivid fashion in his latest angling book, "Tales of Fishing Virgin Seas."⁴

This giant shark was caught by a gaff hook fixed in its tail, and by this it towed the boat around, as is shown in the plates. Finally, after five hours of playing with its captors and towing them for miles, it dived into the depths of the sea, carrying off about 1,600 feet of rope before the hook tore out and set it free. Efforts were made to harpoon it, but the irons rebounded from its enormously thick hide and generally were so bent as to necessitate a visit to the blacksmith's forge.

¹ Proceedings Academy of Natural Sciences of Philadelphia, 1865, Vol. 17, p. 177.

² "Contributions to the Zoology of South Africa," *Zoological Journal*, 1829, No. 16, pp. 443-444—"Illustrations of the Zoology of South Africa," 1849, pl. xxvi, fig.

³ "Systematische Beschreibung der Plagiostomen," 1841, pl.

⁴ New York, 1925, pp. 204-216, pls. cxi and cxii.

Mr. Grey notes that three other specimens of *Rhineodon typus* were seen by members of his party in the immediate vicinity of the point where this attempted capture had been made. From Japanese fishermen the information was elicited that in the neighborhood of Cape San Lucas one of their net boats had been towed for eighteen hours by a big spotted shark before it finally broke the net and got away. Another boat caught a huge *Rhineodon* in its great net but managed to free the fish. Other fishermen told Mr. Grey that they saw them every season in the Gulf of California, and that they were especially numerous around Santa Margarita Island on the west coast of the peninsula of Lower California (in about Lat. 25° N.).

In May, 1926, word came to me that Mr. A. P. Murillo, of Guaymas, Sonora, Mexico, had hunted whale sharks in the waters around Guaymas (*i.e.*, in the central part of the Gulf of California). I at once wrote him and he courteously sent me both photographs and sketches of the fish. The sketches are particularly valuable inasmuch as they elucidate certain points in the structure of the shark which photographs do not bring out, since in these latter only those relatively small parts of the shark show which are above water.

Mr. Murillo unearthed a story of a huge spotted shark captured many years ago, but what is more to the point he recounted two personal experiences with *Rhineodon*. Some years ago he was with a party which harpooned a whale shark. It grounded in shallow water and later was examined at leisure. Again two years ago, while out from Guaymas in a fishing trip, his boat passed within twenty feet of a whale shark. Mr. Murillo's sketches and photographs show him to be perfectly acquainted with *Rhineodon*.

In April, 1926, the yacht *Pawnee*, of the Harry Payne Bingham Oceanographical Expedition, was in the Gulf of California. On board her was Mr. L. L. Mowbray (then of the New York Aquarium, but now in charge of the new aquarium at Bermuda) who had been urged especially to watch out for *Rhineodon*. In all he saw three live fish and one dead one. The largest of the live fish (estimated length, fifty-five to sixty feet) was seen near Cape San Lucas, the others further up in the lower gulf. The dead fish had a long cut on one side as if it had been rammed by a vessel—as indeed Mr. Mowbray conjectured. Such an occurrence has taken place at least once, as I have elsewhere recorded.⁵

⁵ Gudger, E. W., "An Extraordinary Capture of the Giant Shark, *Rhineodon typus*." *Natural History*, 1923, Vol. 23, pp. 62-63, fig.

In June-July, 1926, Mr. Keith Spalding, of Pasadena, California, went on an extensive fishing trip to the lower part of the Gulf of California. Learning that he had seen a *Rhineodon*, I wrote him and in answer he says that he saw it between Cerralvo Island and the peninsula of Lower California. His launch ran alongside it for several hundred yards. One of his party saw another, and he learned that they are frequently seen by sportsmen and the commercial fishermen.

In the summer of 1926, Mr. Mack Sennett, the motion picture producer, headed an expedition, equipped with a newly invented submarine camera, into the Gulf of California, and there made the most remarkable submarine moving pictures of fishes that have ever been produced. I saw the film here in New York, and at once wrote Mr. Sennett, who has been so kind as to present to the American Museum that part of the film showing the whale shark and has written me about the fish. The shark was seen in Los Frales Bay, about 40 miles within the Gulf of California on the peninsula side. Here, then, we have another and most interesting record of *Rhineodon* in these waters.

Messrs. Sennett, Spalding, Murillo, Mowbray and Grey all comment upon the fact that this shark in these waters shows no fear of boats or men. And even when attacked it makes no effort to retaliate, but stolidly pursues its unchecked and for the most part undisturbed way. This is also true of the specimens taken on the coast of Florida, as I have elsewhere recorded in this and other journals. Indeed, from extensive reviews which I have made of the accounts in the literature of whale sharks seen or captured, it is evident that this fish, the largest of the sharks, is entirely inoffensive, and in fact is so sluggish that it offers little or no resistance when being attacked. Mr. Grey's fish seemingly was the most active of any of which we have accounts, but its activity was mainly confined to swimming away, either at the surface or submerged, dragging the boats behind it. Finally it dived so deep as to take out all their line and was not seen again. This final disappearance by diving agrees with what Wright⁶ relates as to the habits of *Rhineodon* in the Seychelles Islands, western Indian Ocean, when harpooned there. It is undoubtedly the fish's chief mode of defense and escape from its would-be captors.

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⁶ Wright, E. Percival, "The Basking Shark," *Nature*, 1876, Vol. 14, p. 315.