

Dizhou Tong (1902-1979)

Dizhou Tong, also called Ti Chou Tung, studied marine animals and helped introduce and organize experimental embryology in China during the twentieth century. He introduced cellular nuclear transfer technology to the Chinese biological community, developed methods to clone organisms from many marine species, and investigated the role of cytoplasm in early development. Tong's administrative and scientific leadership in the fields of marine, cellular, and developmental biology contributed to China's experimental embryology research programs.

Tong was born in a village in Jin County, Zhejiang Province, China, on 28 May 1902. His father was a teacher in the village and was responsible for Tong's early education. Tong's father died when Tong was fourteen years old, leaving his mother to care for Tong and his six siblings. In 1918, at the age of 16, Tong enrolled in a school that trained primary school teachers. A year later Tong left to attend the Xiaoshi Middle School. At the age of seventeen, Tong was the oldest pupil in the class and in 1923 he graduated with the highest grade among his class. That year he entered Fudan University in Shanghai, China. Tong graduated with an undergraduate degree in psychology in 1927.

In 1927 Tong started work as an assistant to professor Bao Cai in the Department of Biology in National Central University in Nanjing, Jiangsu Province, China. Cai was a former teacher of Tong in Fudan University, and he hired Tong to work on embryology. In 1930, Tong married Yufen Ye, a biologist who later specialized in embryology. With financial support from his brothers, Tong started doctoral study in the Universite Libre de Bruxelles in Brussels, Belgium in 1930. There, Tong worked in the laboratory of Albert Brachet and Albert Dalcq, both of whom studied embryos. Tong studied the development of hairy sea squirts (*Asciidiella scabra*), a marine animal that grows on the ocean floor. Tong demonstrated that in hairy sea squirts, during the third division of cells in an embryo, cells divide unequally. Tong published his findings in the 1934 article "Research on the Potentials of Blastomeres in *Asciidiella Scabra*." Tong obtained his doctoral degree in biology from the Universite Libre de Bruxelles in 1934.

At the end of 1934, Tong returned to China and became a professor of biology at Shandong University in Qingdao, Shandong province. In 1937, the Sino-Japanese war began. During this time Shandong University moved several times to southern provinces including Anhui, Hubei, and Sichuan. In 1938, Tong left Shandong University, and worked for several other universities in places more removed from the war. The war hampered Tong's scientific studies. Tong had no microscope when he was in Sichuan province. But Tong managed to buy one at a second hand market using two years of his and his wife's salary.

In the 1940s, Tong began to study goldfish (*Carassius auratus*). Tong removed blastomeres of goldfish embryos to study whether or not the embryos could develop normally without the removed blastomeres. Tong concluded that an organizing center existed in the fish embryo, similar to the Spemann-Mangold organizer in amphibians and to Henson's node in chicks, and that the organizing center and cells in the fish embryo worked together to control the development of the embryo. Tong published his findings on two papers in 1944 and 1945.

After the Sino-Japanese war ended in 1945, Tong became the Dean in the Department of Zoology at Shandong University in 1946. In the same year, Tong founded the Institute of Marine Biology, recruiting several marine biologists including Chengkui Zeng, Chongben He, and Chong Zheng from abroad and offered them professorships. The Institute of Marine Biology was first affiliated with Shandong University, which later became part of the Ocean University of China. In 1948, the US Rockefeller Foundation, headquartered in New York, New York, invited Tong to Yale University as a visiting scholar in New Haven, Connecticut. During his time at Yale, Tong worked in the Osborn

Zoological Laboratory. In the summer of 1948, he was an Independent Investigator at the Marine Biological Laboratory, in Woods Hole, Massachusetts. In March 1949 Tong returned to Shandong University.

On 1 October 1949, the People's Republic of China was founded, followed two months later by the Chinese Academy of Sciences (CAS) in November of 1949. In the same year, Tong was promoted to Vice President of Shandong University. Tong founded the laboratory of experimental embryology within the Institute of Experimental Biology, CAS in 1950. In 1950, Tong, along with two other marine biologists, Chengkui Zeng and Xi Zhang, set up a marine biology lab in Qingdao, a city on the east coast of China. At the time, there were roughly thirty marine biologists in mainland China, and those scientists scattered throughout China. In five months' time, Tong and his colleagues aggregated those scientists in Qingdao, and they founded the Laboratory of Marine Biology of CAS. The laboratory later expanded to the Institute of Oceanology within the CAS, where Tong served as director until his death in 1979. In 1955, Tong quit his position as the Vice President of Shandong University, and he was elected as a fellow of CAS, accepting a position as the head of Division of Biological Sciences in CAS.

Even with his administrative duties, Tong continued his research. Tong started to research on amphioxus, a marine invertebrate thought at the time to be an ancestor of vertebrates. After the founding of the Laboratory of Marine Biology in Qingdao, Tong studied the development of amphioxus during the 1950s and 1960s. Tong published many articles about amphioxus in Chinese journals. Tong and his colleagues used Nile Blue stain to color amphioxus embryos and to track the blastomeres in different stages of development up to 32-cell-embryos. They created a developmental map from zygote to 32-cell embryo of the amphioxus. Tong and his colleagues also tested the developmental potency of different germ layers in 32-cell and 64-cell stage embryos. They grafted germ layers to different places of the embryos, and they observed whether or not the grafted cells had the potency to develop into the same types of surrounding cells. They found that ectoderm was more potent than endoderm.

In 1952, Robert Briggs and Thomas King, working at the Institute for Cancer Research and Lanke-nau Hospital Research Institute, in Philadelphia, Pennsylvania, published the "Transplantation of Living Nuclei from Blastula Cells into Enucleated Frogs' Eggs." This paper exposed Tong to new theories in cellular cloning. Cellular cloning refers to producing genetically identical organisms by transferring the nucleus of a donor cell into a host cell that has had its original nucleus removed. Briggs and King had cloned *Rana pipiens*, a species of frog, by injecting the nucleus of a blastocyst into an egg whose nucleus had been removed. Tong studied Briggs and King's work on nuclear transplantation to study whether the nucleus or the cytoplasm of a cell has greater influence on the development of traits. To test that question, Tong used nuclear transplantation on cells from organisms from different species, called interspecies nuclear transfer. Before he could attempt interspecies nuclear transfer, Tong first had to establish that scientists could clone fish within individual species.

When Tong started his research on nuclear transplantation in the early 1960s, nobody had yet carried out such experiments with fish. To investigate this issue, Tong led a team to clone two different fishes: goldfish, and *Rhodeus sinensis*, a subtropical freshwater fish. The team injected the nucleus of a goldfish blastocyst into a goldfish egg whose nucleus was removed. Some of the clone cells grew into an embryo and developed into juvenile goldfish, the first artificially cloned fish in the world. The similar experiments on *Rhodeus sinensis* also succeeded. Tong published the finding in "Nuclear Transplantation of Fish" in a Chinese journal in 1963. Due to its publication in Chinese, this research was not widely disseminated or read within the international scientific community.

From 1966 to 1976, China underwent the Cultural Revolution, when many intellectuals suffered from prosecution, physical or verbal abuse, and death. Government officials forced Tong to become a janitor and a field laborer and encouraged his wife to leave him, which she refused to do. Despite the harassment, Tong continued his work on nuclear transplantation.

Tong and his researchers began to work in the 1970s on issues about the relative importance of the nucleus and cytoplasm for development, issues not directly addressed by his earlier experiments.

The subjects he chose for the follow up studies were again organisms from *Carassius auratus* and *Rhodeus sinensis*. Tong transplanted the nucleus of an embryonic cell from *Rhodeus sinensis* into a *Carassius auratus* egg, for which the nucleus had been removed. The researchers found that some of the resultant clone cells in the juvenile fish had traits previously found just in *Rhodeus sinensis*. In 1973, Tong published these results, arguing that both the nucleus and cytoplasm of the zygote codetermine the trait of the organism.

In the late 1970s, Tong and his colleagues isolated nuclei from the embryonic cells of *Cyprinus carpio* Linnaeus, or Asian carp, and injected them into European carp eggs, for which the nuclei had been removed. About ten percent of the clones developed into juvenile fish that had the traits of Asian carp and of European carp. This results was Tong's last, and it was published in 1980, a year after his death.

In 1978, Tong became the Vice President of CAS, and he enrolled in the communist party. Tong never stopped teaching, and he had many students. Tong published in public journals to promote the spread of science. On 30 March 1979, Tong died after a heart attack.

Sources

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