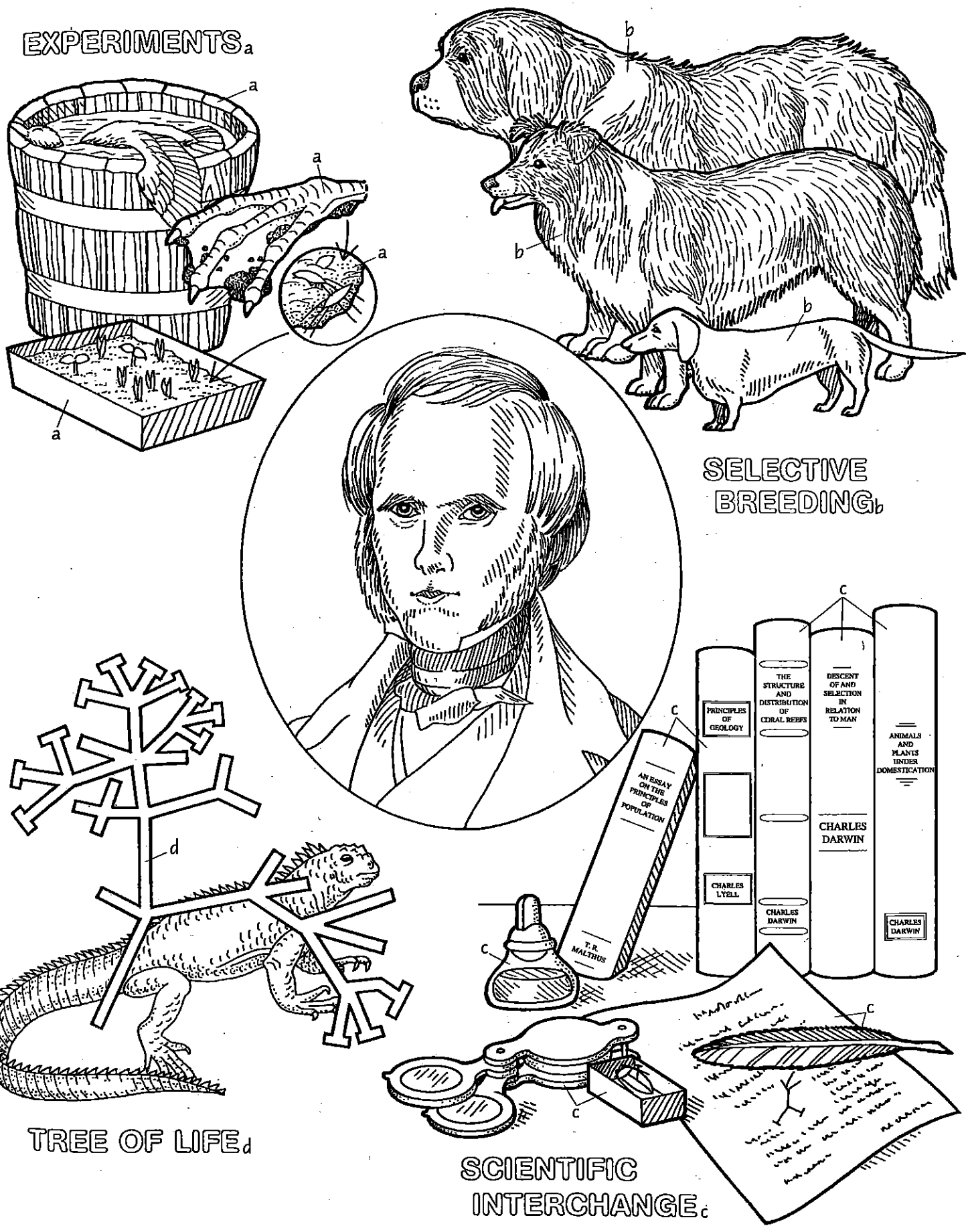
DARWIN'S METHODS



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EXPLAINING SPECIES: DARWIN'S METHODS

The desolate volcanic Galápagos Islands in the Pacific Ocean confronted Darwin with difficult questions about the supposed unchanging character of plants and animals. In seeking answers to these questions, Darwin applied the scientific method: a combination of observing, thinking critically, making connections, proposing hypotheses, and testing ideas through experiments.

Color the seeds and birds representing Darwin's experiments.

Darwin observed that some Galápagos birds and lizards resembled their counterparts across the water in South America. If their ancestors had all come from the mainland, which species could have made it over 1000 kilometers of open ocean, and which would likely have failed? Birds fly. Shellfish float in their larval stages. Tortoises are good swimmers. Lizards ride on branches from rivers into the sea. Amphibians like frogs, on the other hand, cannot survive long in salt water and are almost never found on islands more than 800 kilometers distant from a mainland.

Darwin wondered how the plants got there. Seeds could have drifted to the islands or been carried there by birds. Darwin's experiments showed that seeds could germinate even after soaking in salt water. He obtained seedlings from the seeds in bird droppings and in the mud on the feet of migratory birds. In one experiment, Darwin kept a dead bird in salt water for a month and retrieved viable seeds from its crop! Darwin rejected the prevailing idea that "centers of creation" could account for the unique distribution of plants and animals. He argued instead that natural processes could explain biogeography.

Color the dog breeds produced from selective breeding.

Back in England, Darwin thought more about how species change. He became interested in selective breeding. Domesticated animals and plants exist in nearly endless varieties. To produce a new variety from an existing one, breeders select those individuals with the most desirable traits. Selective interbreeding concentrates these desired traits in succeeding generations. This process has produced huge St. Bernards for rescue missions in high mountains, collies for herding sheep, and streamlined dachshunds for hunting badgers.

Since "artificial selection" worked so well, Darwin made a connection with wild populations and hypothesized that a similar process of "natural selection" could have produced, over long ages of time, the variety of species observed on earth today.

Color the books, correspondence, and publications that represent the activities and interchanges of scientists.

Although Darwin lived a somewhat reclusive life in the country, he did not work in isolation. He consulted colleagues through a voluminous correspondence, wrote extensively in scientific journals, and presented his research at learned societies. In the 10 years following the *Beagle* voyage, Darwin published 4 books, revised 1 book, edited 19 journal volumes, wrote 25 scientific papers, composed a 250-page manuscript on the transmutation of species, and filled 7 notebooks with his ideas.

Darwin read widely and systematically. In 1838, he came across "An Essay on the Principle of Population," written by Thomas Robert Malthus in 1798. This essay gave Darwin insight into a problem he was struggling to resolve. Malthus observed that human populations had the capacity to double in a generation and outstrip the food supply. Since populations at any one time are broadly balanced with the food supply, Malthus proposed that checks must be operating to limit populations. Darwin had not previously thought about the stability of populations. Generalizing from Malthus' ideas about humans, Darwin applied the ideas to the natural world. Animals and plants generally produce vast numbers of offspring, of which very few survive. Darwin reasoned that the weakest and "least fit" individuals are winnowed out in a constant "struggle for existence."

Darwin thought more about what decides which individuals will survive and which will perish without progeny. Offspring are not identical to their parents or to each other. In the actual conditions in which they live, some are stronger and fare better in the environment than others. These mature and pass their favorable traits on to their progeny. This winnowing process, which Darwin called "natural selection," goes on generation after generation. Darwin could now clearly appreciate the overall process of how a population made up of varying individuals can change over time.

Complete the plate by coloring Darwin's Tree of Life.

The process of natural selection gradually reshapes and transforms species over long periods of time. New species arise from previous species. Tracing all species back to their origin, Darwin concluded that all life on earth goes back to a common ancestor. All living creatures are related by a Tree of Life with many diverging branches. Darwin viewed the human species as one twig on the primate branch of the Tree of Life, just as the marine iguana of the Galápagos was a twig from the ancestral South American land iguanid branch. Darwin recognized that chimpanzees and gorillas were "man's nearest allies," and even though very few ape or human fossils were known in his day, he deduced that Africa was probably the cradle of humankind.

Over a century after his death, Darwin endures as a major figure in science, his ideas as controversial and as productive today as they were when he was alive. A keen observer and shrewd reasoner, he generally "got it right" without the technology, biochemistry, and genetic understanding that support evolutionary research nowadays. Modest in personal demeanor but an earth-shaking asteroid in the force of his ideas, Darwin remains for many geologists, biologists, and anthropologists the model of a scientist's scientist.