Neutrophils, a key component of the innate immune response, play a fundamental role in defending the body against infections. As the most abundant type of white blood cell, they form the first line of immune defense by sensing and responding to invading pathogens. Their unique structure, including a multi-lobed nucleus and granules packed with powerful enzymes, enables them to act rapidly and effectively. Neutrophils destroy harmful microbes by engulfing them, releasing toxic substances, and forming web-like structures called neutrophil extracellular traps (NETs) that trap and neutralize pathogens.

While neutrophils were once thought to be simple and short-lived, new research shows that they are a surprisingly heterogenous population of cells. In diseases like cancer and autoimmune disorders, we see a variety of neutrophil subtypes emerge. In fact, the appearance of certain neutrophil subpopulations has been linked to disease progression. The process of neutrophil production and release from the bone marrow, called granulopoiesis, is tightly regulated by signals such as granulocyte colony-stimulating factor (G-CSF). However, other molecular cues—like pathogen-associated molecular patterns (PAMPs) from microbes and danger-associated molecular patterns (DAMPs) from damaged cells—also play a role in accelerating or altering this process.

To explore these dynamics in a human-relevant model, our research uses induced pluripotent stem cells (iPSCs), which are ordinary human cells reprogrammed in the lab to behave like stem cells. These iPSCs can be guided to become myeloid progenitors—the early cells that develop into neutrophils—allowing us to study how PAMPs and DAMPs influence their growth and specialization in a controlled setting. This laboratory-based approach provides a promising alternative to animal models and offers deeper insights into human immune cell development.

We aim to uncover how these environmental signals affect the types and functions of neutrophils that are produced, as well as how these cells interact with other immune cells such as T lymphocytes. By studying iPSC-derived neutrophils, we can observe how they migrate, fight infection, and release NETs in response to different stimuli. Ultimately, this work will enhance our understanding of how neutrophil diversity arises—especially during disease—and may lead to new treatment strategies for conditions involving immune system dysfunction.