Most eusocial and primitively eusocial insects demonstrate a degree of specialization within the colony, varying from responsibilities in rearing a brood to foraging in the field to sustain the colony. This foraging specialization has been noted in strictly eusocial organisms such as honey bees (Page and Amdam, 2007) but has been scarcely documented in less elaborate social systems such as the bumble bee. Such species have been anecdotally observed to retain evolutionarily ancestral mechanisms for regulating reproduction, and co-opting these mechanisms to regulate the division of labor amongst workers.

**Prior Observations:**
- Honey bee workers who forage for pollen develop larger ovaries and higher vitellogenin titers than workers foraging for nectar, despite both groups remaining non-reproductive.
- The ground-plan hypothesis states that ancestral mechanisms once used to regulate foraging patterns remain, where pollen (protein) is used to produce eggs, and nectar (carbohydrates) is used for self-maintenance (Page and Amdam, 2007).
- The related (and largely unstudied) bumble bee does have specialists and generalists within a colony.
- Typically only the queen lays eggs during the season, but individuals still may express measures of reproductive fitness.

**Research Goals:**
- The primary question of this project asks whether through the course of social development, do any solitary tendencies remain within the behaviors of bumble bee specialists?
- If so, can these tendencies be quantitatively measured through physical manifestations, such as ovary development, ovary size, bee size, and haemolymph composition?

**Methods**
- Radio Frequency Identification Tagging and Logging
- Physical Measurements and Dissections
- Micro-capillary Haemolymph Extractions
- Gel Electrophoresis
- Antibody staining and confocal microscopy to measure brain amine titers.
- Ether extractions to quantify the fat content (nutritional resources) of foraging specialists.
- Using gel electrophoresis to further measure vitellogenin (egg precursor protein) concentration.
- Bumblebees offer the chance to compare worker foraging specialization with direct reproductive ability in the same individuals since at the end of the season queen control erodes and workers reproduce. Determine if pollen specialists are more reproductively developed at the end of the colony cycle.

**Experimental Setup:**
- The related (and largely unstudied) bumble bee does have specialists and generalists within a colony. This foraging specialization has been noted in strictly eusocial organisms such as honey bees (Page and Amdam, 2007) but has been scarcely documented in less elaborate social systems such as the bumble bee. Such species have been anecdotally observed to retain evolutionarily ancestral mechanisms for regulating reproduction, and co-opting these mechanisms to regulate the division of labor amongst workers.

**Visual Scale of Ovary Development**
- **Fig. 1** Ovary development scale based on the Michener and Wille (1961) framework.

**Head Size of Specialists/Generalists**
- **Fig. 2** All measurements taken at the conclusion of feeding period.

**Results**
- Dissection Samples of Ovary Development After 8 Days Ad Libitum Feeding

**Conclusions**
- After conducting t-test comparisons between specialists as well as generalists, the following results were gathered:
  - **Ovary Development**
    - Pollen to nectar specialists $p = 0.10$
    - Nectar specialist to generalist $p = 0.15$
    - Pollen specialist to generalist $p = 0.03$
  - **Head Size**
    - Pollen to nectar specialists $p = 0.08$
    - Nectar specialist to generalist $p = 0.50$
    - Pollen specialist to generalist $p = 0.16$

  The only statistically significant relationship appeared to be the comparison of ovary development between pollen and specialists and generalists, indicating a difference in ovary development between pollen specialists and average workers. Interestingly, head size appeared to be larger for nectar foragers, although not statistically significant.

**Future Research**
- Using gel electrophoresis to further measure vitellogenin (egg precursor protein) concentration.
- Antibody staining and confocal microscopy to measure brain amine titers.
- Ether extractions to quantify the fat content (nutritional resources) of foraging specialists.
- Bumblebees offer the chance to compare worker foraging specialization with direct reproductive ability in the same individuals since at the end of the season queen control erodes and workers reproduce. Determine if pollen specialists are more reproductively developed at the end of the colony cycle.

**Acknowledgements**
A special thanks to Tara Scully and the Harlan Summer Undergraduate Research Program for providing guidance and financial support, as well as Dr. Adam Smith for his mentoring and laboratory resources.

References available upon request.