The following two chapters investigate the possibility of using embodied evolution for the emergence of organisms. These investigations consider the principal challenge of birth in the case of transient organisms, e.g. where individual modules can aggregate into an organism and disaggregate at will.

The scenario envisioned in these chapters is that of a swarm of modular robots situated in an environment where it is beneficial to aggregate into organisms in some circumstances. Moreover we assume that the system designers do not know beforehand whether the environment requires aggregation and in which situations. Thus, we exclude the possibility of hand-designing controllers to solve this scenario. Instead of directly designing controllers we aim to design an evolutionary algorithm that can develop controllers in real time such that modules aggregate and disaggregate as required by the circumstances.
The main research question in these chapters is: *Is embodied evolution powerful enough to evolve (dis-)aggregation behaviour using indirect fitness in a swarm of robots?*

To answer this question we have used an evolutionary algorithm that runs on-line and on-board that was developed in our lab. However, because we do not know if and when aggregating is beneficial we cannot design a traditional fitness function that directly rewards (dis-)aggregation. Thus, evolution must rely on indirect, environmental fitness, that is, on the fact that in certain situations being a part of an organisms gives an advantage over not being in an organism (and the other way around).

In the first chapter the robots are placed in an environment where being in an organism allows the robots to harvest more energy. In the second chapter being in an organism is regularly required to overcome an obstacle, while other times specifically *not* being in an organism is required. There is still an explicit fitness function used in our algorithm in both cases, but this function rewards either the amount of energy gathered or the level of task completion. In both cases forming organisms is part of maximising the fitness, but in an indirect manner.

The robots modelled in RoboRobo are an approximation of the robots developed in the SYMBRION project (see Figure 1.2b). Besides sensors, communication and processing capabilities, these robots have two important features: 1) they are independently mobile (e.g. they have wheels of some sort) and 2) they can create rigid connections with other robots and thus form an organism.