5.2 Gonads

Gonadal formation is informed by gene expression that directs cells to migrate to different parts of the undifferentiated gonad, but the association between genes and gonadal development is extraordinary complex, in part because mutation accumulation often renders the action of specific genes inadequate to form the gonad, so new genes are recruited to stabilize the system. There is complexity and plasticity in the process of gonad formation despite the existence of genes that are generally associated with producing gonads that will ultimately make sperm, and those that ultimately will make eggs. Some intersex variations (see Intersex module), can result in individuals that do not clearly differentiate their gonads, or some that can potentially produce both types of gametes.

When gonads are present, typically ovaries produce eggs, and testes produce sperm, but they evolved from an ancestral gonad that produced only one type of gamete (isogametic), and these gonads were repurposed to produce two types of gametes, as well as to produce important hormonal products that help to organize bodies and their fundamental functions (including but not exclusive to reproduction). Because of this evolutionary history, gonads differentiate from an undifferentiated gonadal structure that is closely associated with renal development in all vertebrates. The urogenital ridge starts differentiating early in all embryos, and the genital ridge which is medial to the urinary ridge gives rise to an indifferent gonad. Soon after, undifferentiated germ cells migrate from extra-embryonic endoderm to the genital ridges. Depending on the location where the stem cells end up, they will become sperm or eggs. If the migrating stem cells populate the deeper or medullary region of the differentiating gonad, they will eventually become sperm, but if they populate the cortex or peripheral region, they will become eggs. This gonadal separation is not always clear cut, for example reproductive adult female moles of several species are known to have ovotestes, a type of gonad that has both ovarian and testicular tissue. These females produce eggs and high levels of testosterone, presumably to help them maintain their territories year round.

As mentioned before, many organisms do not develop gonads until they are ready to reproduce and therefore they cannot be categorized as potentially male or female for at least some portion of their life. Sometimes these are called simply juveniles or immatures, even when they can be as old as reproductive individuals. For example some fish that change sex depending on the social environment, can live for years or decades in this non sexual state, before turning into a male or a female (e.g. anemone fish), and rather than classifying them according to their potential sex, which will remain unknown unless they are provided with the opportunity to breed, they could be classified as neither male, nor female (or non-sexuals). This category must be distinct from juvenile which for most species is a time limited period of growth before becoming a reproductive adult. In addition, individuals sometimes may be able to produce both types of gametes as explained in the gynandromorphs, and some intersex variations, so the category “both” should be added to gamete type.

Phenotypic plasticity: Gonads can change in size increasing or decreasing gamete production depending on the social and abiotic environment. Testes in mammals, birds and insects can increase in size in social environments that foster sperm competition, but sometimes testes will not grow if males are reproductively suppressed by dominant males. Ovaries may remain suppressed and follicles may not be released when a dominant breeder prevents other females from reproducing. When environmental conditions are good, snakes produce more eggs, but in years of low food abundance they may forgo reproduction altogether.

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