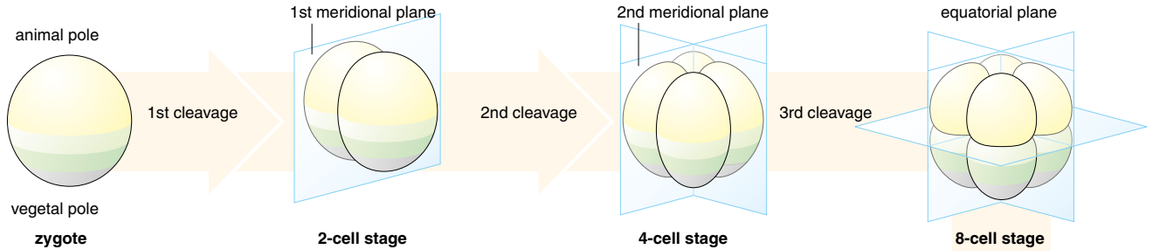

From zygote to multicellular organism

Blue whales, sea urchins, fruit flies and humans – they each develop from one single cell called a *zygote* by countless mitoses. The basis for species-specific development and the composition of an organism is determined by its genes. Environmental factors can have a modifying effect.

The first divisions of a fertilized egg cell have been well examined in sea urchins. The egg cell has little yolk and is polar. The region containing more yolk and pigment is called the *vegetal pole*, whereas the other region side is called the *animal pole* (see fig.). After fertilization by a sperm, mitoses start in the generated zygote. After the first few cell divisions, the cleavage furrows can clearly be seen running externally from the animal pole to the vegetal pole and also in the equatorial plane. The cleavage furrows divide the cytoplasm of the egg cell into cells of about the same size (*blastomeres*). This type of cleavage is called complete or holoblastic and is typical for cells with little yolk.

The blastomeres divide further without an increase of cytoplasm. Thus, the daughter cells become smaller and receive part of the maternal cytoplasm with its unequally distributed components. All cells have the same genetic set-up but differ in the composition of their cytoplasm. At first, a solid ball forms (*morula*) from which a hollow ball develops (*blastula*). The developing cavity is called *blastocoel*.

After these cleavages, cellular movement and cellular replacement follow, which are together referred to as *gastrulation*. Three cell groups (*germ layers*) form from which the organs later develop. Initially, some cells migrate from the vegetal pole into the cavity of the blastula. These are the precursors of the middle germ layer (*mesoderm*). Subsequently, the vegetal pole invaginates and the shape of the embryo becomes similar that of a ball with a dent. The generated *gastrula* has a primitive gut (archenteron) with an opening to the outside called the blastopore. The cells of the primitive gut (= digestive tract) become the inner germ layer (*endoderm*). The outer cell layer becomes the *ectoderm*. Skin and nervous system form from the ectoderm. The mesoderm forms connective tissue, muscles and the lining of the coelom. The endoderm forms the epithelial lining of the intestines. The gastrula develops into a planktonic larva (pluteus) that becomes a sea urchin by metamorphosis.

Egg and cleavage types

In all multicellular animals, the first steps during development from a zygote to a multicellular organism - cleavage and gastrulation - basically follow the same principles. If we compare the first cleavage stages, we find differences especially in the size and the arrangement of the blastomeres (*blastomere symmetry*).

The different *cleavage types* depend on the amount and distribution of the yolk in the egg cell.

Yolk

Yolk is the nutritive reserve material of an egg cell, e.g. proteins, amino acids, glycogen, lecithin and vitamins stored for the metabolism of the embryo while it cannot take up nutrients.

Yolk is produced in the oocyte during *oogenesis* by helper cells in the female. The helper cells surround the egg cell as a follicle. In other cases, yolk is also secreted by the ovaries.

The yellow of a chicken's egg is the yolk-enriched egg cell, which is surrounded by egg white (albumen) secreted by the ovaries. The egg cell, yolk and egg integument or egg shell together are called the *egg*.

Eggs rich in yolk are often produced by animals that generate only a few eggs, which usually receive intensive *brood care*. Eggs with little yolk are typical for animals that undergo mass reproduction. Mammalian eggs also have little yolk as the mothers carry their embryos inside the womb and nourish them through a *placenta*; the embryos therefore need fewer reserves.

Complete cleavage

Fertilized egg cells with little yolk divide their entire cytoplasm into two cells of about the same size (*blastomeres*). The first two cleavages are meridional, whereas the third is more or less equatorial. It divides the embryo equally into 8 cells of about the same size or unequally into four larger and four smaller cells, as in the sea urchin (see page 48). Further cleavages are *radial*, angularly shifted (*spiral*) or shifted sideways (*bilateral*) to the animal pole. In this way, the later axes of the body are determined.

Partial cleavage

Fertilized egg cells rich in yolk cleave only partially (*discoidal* or *superficial*). In insects, the central nucleus initially divides many times. The daughter nuclei migrate to the periphery of the zygote. Here, the cell surrounds itself with cell membranes (*superficial blastula*). In reptiles and birds, only the *germinal disc* on the animal pole is cleaved (*blastodisc*). The yolk is not divided.