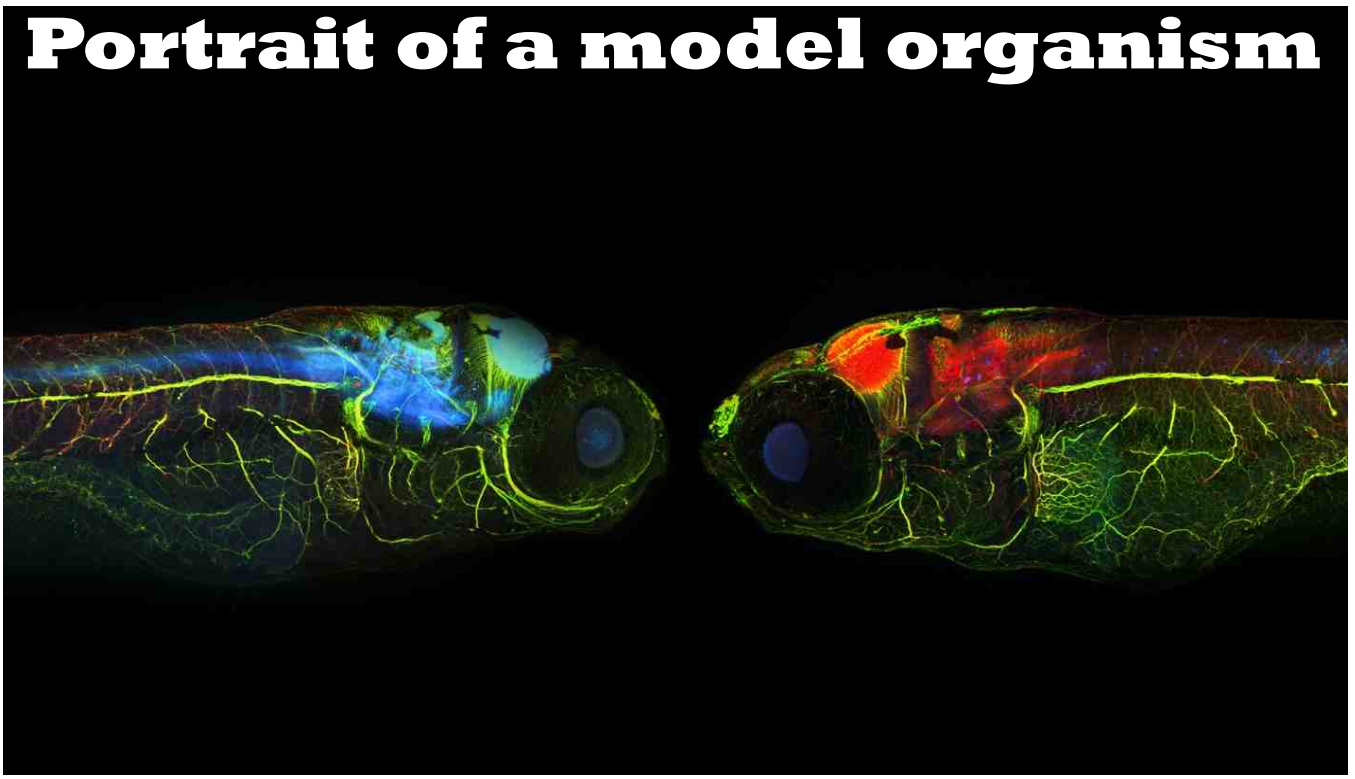
Portrait of a model organism



The zebrafish (Danio rerio)

cellular organisms - Eukaryota - Fungi/Metazoa group - Metazoa - Eumetazoa - Bilateria - Coelomata -Deuterostomia - Chordata - Craniata - Vertebrata - Gnathostomata - Teleostomi - Euteleostomi -Actinopterygii - Actinopteri - Neopterygii - Teleostei - Elopocephala - Clupeocephala - Otocephala -Ostariophysi - Otophysi - Cypriniphysi - Cypriniformes - Cyprinoidea - Cyprinidae - Rasborinae - Danio -Danio rerio

The zebrafish (Danio rerio) is a tropical freshwater fish belonging to the minnowfamily (Cyprinidae) of order Cypriniformes. Native to the Himalayan region, it is a popular aquarium fish, frequently sold under the trade name zebra danio. The zebrafish is also an important vertebrate model organism in scientific research.

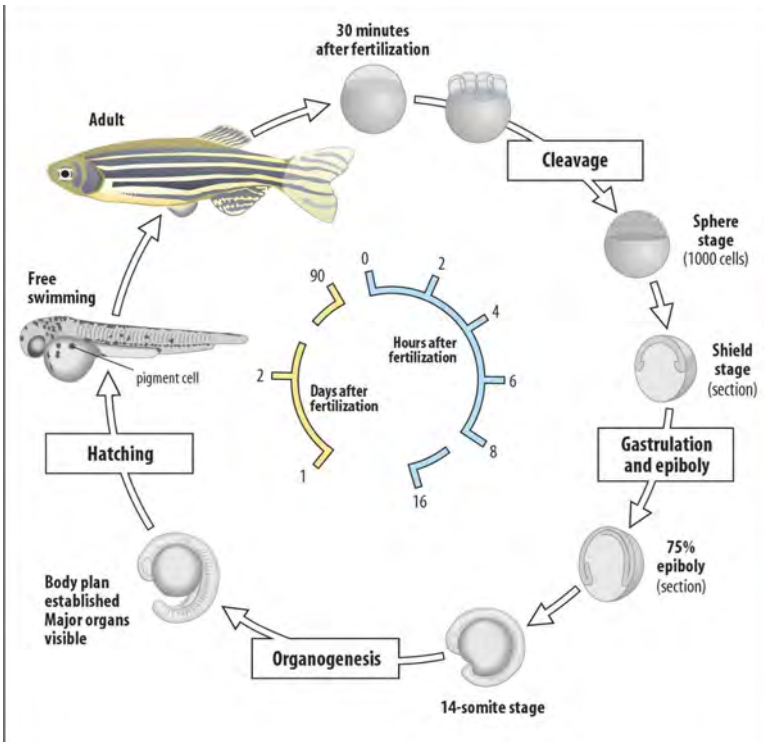
Geographical Distribution

The zebrafish is native to the streams of the southeastern Himalayan region,and is found in parts of India, Pakistan, Bangladesh, Nepal, and Burma.[10] The species arose in the Ganges region in eastern India, and commonly inhabits streams, canals, ditches, ponds, and slow-moving or stagnant water bodies, including rice fields. Zebrafish have been introduced to parts of the United States, presumably by deliberate release or by escape from fish farms.

Why named zebrafish?

The zebrafish is named for the five uniform, pigmented, horizontal, blue stripes on the side of the body, which are reminiscent of azebra's stripes, and which extend to the end of the caudal fin. Its shape is fusiform and laterally compressed, with its mouth directed upwards. The male is torpedo-shaped, with gold stripes between the blue stripes; the female has a larger, whitish belly and silver stripes instead of gold. Adult females will exhibit a small genital papilla in front of the anal fin origin. The zebrafish can grow to 6.4 cm (2.5 in) in length, although it seldom grows larger than 4 cm (1.6 in) in captivity. Its lifespan in captivity is around two to three years, although in ideal conditions, this may be extended to five years.

The approximate generation time for Danio rerio is three to four months. A male must be present for ovulation and spawning to occur. Females are able to spawn at intervals of two to three days, laying hundreds of eggs in each clutch.



Advantages and disadvantages of using zebrafish in labs

Advantages:

- They can be kept at fairly high densities in a small tank
- They lay large numbers of easily collectible eggs
- The eggs are clear and easily observed and manipulated
- They develop fast
- Their generation time (egg to adult) is short
- They are vertebrates
- Expense. Fish are cheaper to maintain than mice, but more expensive than flies--another powerful model organism.

Disadvantages:

- They require water systems to maintain them
- They are not mammals and are not as closely related to humans as a mouse is.
- Reverse genetics has not been worked out for zebrafish as it has in the mouse.
- No way of targeting mutations. In mice, for example, you can "knock out" a gene if you have the sequence, and ask why it is needed. In zebrafish, we create random mutations and look for specific defects.
- Fly (Drosophila) genetics is much more powerful than fish genetics, because many genetic tools and tricks have been designed over the course of the last 100 years. We need to catch up.

Why are zebrafish ideal models for development and disease research?

• Zebrafish are vertebrates. Like humans, they have a backbone. This means that they are more closely related to humans than commonly used invertebrate models such as insects and worms (Drosophilia - fruit flies and Caenorhabditis elegans - nematodes) which do not have backbones. Because zebrafish are more closely related to humans, they are more likely to be similar to them in many biological traits than a more distantly related organism. These biological traits would include genes, developmental processes, anatomy, physiology, and behaviors. This is an advantage that invertebrate lab animals do not share with humans. The invertebrates are more appropriately used in comparisons at the cellular or biochemical level of organization where they share many features with humans.

• No single model is perfect, but zebrafish have features that make them easy to maintain, manipulate, and observe in the lab. They do well in many environments, and their small size, their ability to be kept together in large numbers, and the ease with which they can be bred makes them a favored model. Breeding and getting eggs from the zebrafish is relatively easy. Their eggs are externally fertilized, produced regularly in large numbers, and are non-adhesive. Their embryos develop rapidly, and are clear throughout their development. Their embryos are also smaller than many vertebrate embryos and contain smaller numbers of cells. It is easier to trace the development of individual cells.

• Females lay large quantities of eggs. For many types of genetic analysis you need to look at many different embryos at many different stages to understand what the problem is with a given mutation.

• The embryos develop outside the mother's body, so you can have easy access to them. In contrast, mouse embryos develop inside the mother, and you have to kill

the mother to get at them. This would have to be done at each of the stages of development you want to look at. Once you do this, of course, the embryos die as well as the mother, so you are very limited in the types of experiments you can do.

• Zebrafish embryos are transparent. This means you can watch development as it happens in living embryos. You can see internal organs, such as the brain, heart, blood, muscles, etc. In addition, you can monitor the behavior of single cells in live embryos and watch the cells divide and through dyes, trace where each cell's "daughters" go in making up the complete organism. It is not possible to achieve this resolution with other systems.

• The embryos develop quickly. They go from a single cell to something that is recognizable as a tiny fish within 24 hours. Mice take 21 days.

• You can physically manipulate the embryos. By this I mean you can transplant single cells or groups of cells into host embryos. This kind of experiment is performed frequently to analyze the behavior of cells at different stages, or to ask how mutant cells behave in wildtype embryos. This can give us a lot of information about how certain gene products act. In addition, fertilization of the egg can be manipulated so that the embryo contains only it's mother's genes. This is done by exposing the sperm to ultraviolet light which destroys the genes it contains from the male. This allows scientists to study recessive mutations since the characteristics and defects are inherited from only one parent.

• There is a large community of researchers willing to share their knowledge of the more

How does zebrafish research help humans?

We can't do research on humans so we find models that mimic the human, do the research using zebrafish, and then try to figure out how to extrapolate the data to humans... not an easy task. We are really never sure how exactly the data will match what we would have found if we use humans. Now that we know the genome of the human and are working on many other organisms, that process is getting easier. For example, if we find some gene altered in the zebrafish due to exposure to a toxicant or from a disease, then we can use the database to search for a similar gene in humans. We also now know that there is considerable conservation of pathways across species. Zebrafish are vertebrates. This means that they are more closely related to humans than invertebrates. By virtue of their being more closely related to humans, they are more likely to be similar in any biological trait than is a more distantly related organism.

- Some zebrafish mutants are known to develop and duplicate certain conditions and diseases common to humans. In studying their more simplified make up, it is frequently possible to determine what genes are involved and then compare them to the equivalent genes within the human genome.

- Although zebrafish and humans are obviously very different, their embryonic development is remarkably similar. Furthermore, it is becoming more and more clear that all vertebrates follow an evolutionarily-conserved developmental program. This conservation extends even to the molecular level--where similar genes perform similar functions in many different species. You cannot do the kind of experiments in humans that are outlined above, and which are necessary to understand a given biological process, and how genes act to make that process work.

- There are many zebrafish mutants with defective blood (studied primarily by Len Zon's lab - Massachusetts General Hospital) or defects in heart development (Mark Fishman's Lab - Massachusetts General Hospital, Didier Stainier's Lab - University of California, SF, or Debbie Yelon's lab - Skirball Institute, NYU School of Medicine). It is likely that blood function and heart development in zebrafish are similar to blood function and heart development in people. Some of these mutations might mimic human syndromes, and understanding them will provide us with valuable insight as to the underlying problem. Such an understanding could lead to new treatments. In addition, many of the proteins involved in early development are critical in later life. Defects in these proteins, or in the regulation of their expression, can lead to tumors later in life.

The Zebrafish Information Network (ZFIN) is an online biological database of information about the zebrafish (Danio rerio). The zebrafish is a widely used model organism for genetic, genomic, and developmental studies, and ZFIN provides an integrated interface for querying and displaying the large volume of data generated by this research.

To facilitate use of the zebrafish as a model of human biology, ZFIN links these data to corresponding information about other model organisms (e.g., mouse) and to human disease databases.

Abundant links to external sequence databases (e.g., GenBank) and to genome browsers are included. Gene product, gene expression, and phenotype data are annotated with terms from biomedical ontologies. ZFIN is based at the University of Oregon in the United States, with funding provided by the National Institutes of Health (NIH).

ZFIN also maintains a database of zebrafish-related publications, laboratories, people, and companies.
In addition to its specialized search interfaces, ZFIN provides a Google-like global site search.
ZFIN's community wiki gives zebrafish researchers the ability to share information about laboratory protocols and antibodies.

Zebrafish Information Network

ZFIN's relational database interface provides query forms and display pages for the following biological data types:

Genes, markers, and clones

Gene expression

Antibodies

Sequence alignments (BLAST)

Mutants and transgenic lines

Anatomy

Genetic maps