VERTEBRATES VS INVERTEBRATES CHART Updated Version

Vertebrates vs invertebrates chart is an essential tool for understanding the fundamental differences and similarities between two major groups of animals. These classifications help biologists, students, and nature enthusiasts grasp the diversity of the animal kingdom, their biological features, and their ecological roles. In this comprehensive guide, we will explore the key aspects of vertebrates and invertebrates, analyze a comparative chart, and highlight the significance of these classifications in biology.

Understanding the Basics: What Are Vertebrates and Invertebrates?

What Are Vertebrates?

Vertebrates are animals characterized by the presence of a backbone or spinal column. They belong to the phylum Chordata and are part of the subphylum Vertebrata. Vertebrates are highly evolved animals with complex structures, advanced nervous systems, and specialized organs.

Key features of vertebrates include:

- Presence of a backbone or spinal column
- Developed brain and nervous system
- Endoskeleton made of bone or cartilage
- Closed circulatory system
- Highly developed sensory organs

What Are Invertebrates?

Invertebrates, on the other hand, are animals that lack a backbone or spinal column. They constitute the vast majority of animal species, making up about 95% of all animals on Earth. Invertebrates belong to various phyla, including Arthropoda, Mollusca, Annelida, Cnidaria, and others.

Key features of invertebrates include:

- Absence of a backbone
- Variety of body plans (e.g., segmented, soft-bodied, exoskeleton-covered)

- Wide range of reproductive and respiratory strategies
- Less complex nervous systems compared to vertebrates

Comparative Chart of Vertebrates and Invertebrates

A vertebrates vs invertebrates chart provides a clear side-by-side comparison of their characteristics, classification, diversity, and ecological significance.

Key Differences

AspectVertebratesInvertebrates
Number of speciesApproximately 64,000 known speciesOver 1.3 million known species, with many more undiscoveredPresence of backboneYesNoBody supportEndoskeleton (bone or cartilage)Varies ? soft-bodied or exoskeletonsNervous systemHighly developed, complex brainLess complex, nerve nets or gangliaCirculatory systemClosed circulatory systemOpen or closed, varies among groupsReproductionMostly sexual, with some species capable of asexual reproductionPrimarily sexual, with diverse reproductive strategiesHabitat diversityMostly terrestrial and aquatic habitatsExtremely diverse ? marine, freshwater, terrestrial

Major Phyla of Invertebrates and Their Characteristics

Invertebrates are classified into numerous phyla, each with distinctive features. Some of the most prominent include:

Phylum Arthropoda

- The largest invertebrate phylum, including insects, arachnids, crustaceans, and myriapods.
- Features include an exoskeleton made of chitin, segmented bodies, and jointed appendages.
- Adapted to nearly all habitats, from deep oceans to terrestrial environments.

Phylum Mollusca

- Includes snails, clams, squids, and octopuses.
- Characterized by a soft, unsegmented body, often with a calcium carbonate shell.
- Many have a well-developed muscular foot and a radula for feeding.

Phylum Annelida

- Comprises segmented worms like earthworms and leeches.

- Features include a segmented body, a closed circulatory system, and a nervous system with ganglia.

Phylum Cnidaria

- Includes jellyfish, corals, and sea anemones.
- Known for their stinging cells called cnidocytes and radial symmetry.
- Mostly aquatic, with simple nerve nets and a basic digestive cavity.

Evolutionary Significance and Adaptations

Understanding the differences between vertebrates and invertebrates through a chart reveals much about their evolutionary adaptations and ecological roles.

Evolutionary Pathways

- Vertebrates are considered more evolutionarily advanced, with complex organ systems and a backbone that provides structural support.
- Invertebrates exhibit a wide range of adaptations to diverse environments, including exoskeletons, specialized appendages, and unique reproductive strategies.

Adaptations for Survival

- Vertebrates have developed advanced sensory organs, efficient circulatory and respiratory systems, and complex behaviors.
- Invertebrates often possess specialized body parts such as claws, tentacles, or shells, enabling them to thrive in various habitats.

Importance of the Vertebrates vs Invertebrates Chart

A detailed chart comparing vertebrates and invertebrates serves multiple purposes:

- Educational tool for students learning animal biology
- Reference for zoologists and researchers studying biodiversity
- Helping in conservation efforts by understanding species diversity and ecological roles
- Assisting in identification and classification of unknown species

Conclusion: The Significance of Recognizing Animal Diversity

The vertebrates vs invertebrates chart encapsulates the vast diversity of the animal kingdom, highlighting how different groups have evolved unique features to adapt and survive. Recognizing these differences is fundamental for understanding ecological dynamics, evolutionary biology, and conservation strategies. Whether you're a student, educator, or enthusiast, such a chart provides a clear, visual summary of one of the most fascinating aspects of biology?the incredible diversity of animal life on Earth.

Vertebrates vs Invertebrates Chart: An In-Depth Examination of Animal Classification

Understanding the diversity of the animal kingdom is a fundamental aspect of biological sciences. Among the foundational classifications, the dichotomy between vertebrates vs invertebrates forms a cornerstone for taxonomy, ecology, and evolutionary biology. A comprehensive vertebrates vs invertebrates chart not only simplifies the vast array of animal species but also provides insights into their structural, functional, and ecological differences. This article aims to explore these distinctions thoroughly, analyzing the significance of such charts and their role in scientific understanding.

Introduction to Vertebrates and Invertebrates

The animal kingdom is remarkably diverse, encompassing over a million described species with estimates suggesting millions more yet to be discovered. Broadly, animals are categorized into two primary groups based on the presence or absence of a backbone: vertebrates and invertebrates.

Vertebrates are animals possessing a vertebral column, or backbone, which is part of an internal skeleton. This group includes mammals, birds, reptiles, amphibians, and fish, collectively known as the chordates.

Invertebrates, on the other hand, lack a backbone. They make up the vast majority of animal species, including insects, mollusks, worms, cnidarians, echinoderms, and many others.

The stark contrast between these two groups is encapsulated in various classification charts, which serve as visual aids to understand their differences and similarities.

The Role of the Vertebrates vs Invertebrates Chart in Biological Education and Research

A well-constructed vertebrates vs invertebrates chart functions as an essential educational tool, aiding students and researchers in grasping complex taxonomic relationships. These charts typically illustrate key features such as:

- Structural differences (presence of backbone, body symmetry)
- Reproductive strategies
- Developmental stages
- Ecological roles
- Evolutionary relationships

By synthesizing vast amounts of biological data into visual formats, these charts facilitate:

- Quick comparison of major animal groups
- Identification of characteristic features
- Understanding evolutionary lineages
- Recognizing biodiversity patterns

Furthermore, these charts assist in ecological studies, conservation planning, and understanding the evolutionary adaptations that have allowed animals to thrive in diverse environments.

Structural and Anatomical Differences

Vertebrates

Vertebrates possess a well-defined internal skeleton composed of bone or cartilage, which provides support and protection for internal organs. Key features include:

- Vertebral column: Protects the spinal cord and provides structural support.
- Endoskeleton: Made of calcified cartilage or bone.
- Complex nervous system: Including a well-developed brain.
- Closed circulatory system: Usually with a heart.
- Bilateral symmetry: Most are bilaterally symmetrical.
- Body cavity: Typically coelomate.

Invertebrates

In contrast, invertebrates exhibit a wide array of structural forms, often lacking a backbone. Their characteristics include:

- Exoskeleton or no skeleton: Some have external shells (e.g., mollusks), others lack any rigid support.
- Varied body plans: Radial symmetry (e.g., cnidarians), bilateral symmetry, or asymmetry.

- Simpler nervous systems: Ranging from nerve nets to complex centralized brains (e.g., cephalopods).
- Open circulatory systems: In many, blood flows freely within body cavities.
- Diverse reproductive strategies: From hermaphroditism to complex life cycles.

Summary Table: Structural Features

Feature	Vertebrates	Invertebrates
Backbone	Present	Absent
Skeleton	Internal (endoskeleton)	External (exoskeleton), absent, or varied
Symmetry	Bilateral	Bilateral, radial, or asymmetrical
Nervous system	Well-developed brain and spinal cord	Ranges from simple nerve nets to complex brains
Circulatory system	Closed system with heart	Open or closed, varies widely

Taxonomic Diversity and Examples

The vertebrates vs invertebrates chart often emphasizes the incredible diversity within each group, highlighting representative species and their ecological niches.

Major Groups of Vertebrates

- Mammals (e.g., humans, whales, bats): Warm-blooded, hair/fur-covered, produce milk.
- Birds (e.g., eagles, sparrows): Feathers, beaks, lay eggs, capable of flight.
- Reptiles (e.g., snakes, lizards): Scaly skin, lay eggs, cold-blooded.
- Amphibians (e.g., frogs, salamanders): Moist skin, undergo metamorphosis.
- Fish (e.g., sharks, salmon): Gills, scales, most aquatic.

Major Groups of Invertebrates

- Insects (e.g., beetles, butterflies): Six legs, three body segments.
- Mollusks (e.g., snails, octopuses): Soft-bodied, often with shells.

- Annelids (e.g., earthworms): Segmented worms.
- Cnidarians (e.g., jellyfish, corals): Radial symmetry, stinging cells.
- Echinoderms (e.g., starfish, sea urchins): Radial symmetry, spiny skin.
- Arthropods (e.g., spiders, crustaceans): Exoskeleton, jointed limbs.

Evolutionary Perspectives and Phylogenetics

A key aspect of vertebrates vs invertebrates chart is illustrating evolutionary relationships. Molecular studies and fossil records have revealed that:

- Vertebrates are a relatively recent evolutionary branch within the chordates.
- Invertebrates constitute a paraphyletic group, with some invertebrate lineages being more distantly related.
- The evolution of a backbone in vertebrates is a significant adaptation that allowed for increased mobility and complex behavior.

Phylogenetic trees derived from genetic data often depict:

- Divergence points between major animal groups.
- The evolutionary origin of features like the backbone, exoskeleton, or nervous systems.
- The relationship between simple invertebrates and more complex vertebrates.

This evolutionary context enhances the understanding provided by the vertebrates vs invertebrates chart, transforming it from mere classification to an exploration of animal history.

Ecological and Environmental Significance

Both vertebrates and invertebrates play critical roles in ecosystems. Their differences influence their ecological functions:

- Invertebrates often dominate in number and biomass, especially in soil, freshwater, and marine environments.
- They serve as primary consumers, decomposers, and prey for vertebrates.
- Vertebrates often occupy higher trophic levels, acting as predators, herbivores, or ecosystem engineers.

A vertebrates vs invertebrates chart can include data on:

- Population sizes
- Habitat ranges
- Ecological niches
- Conservation status

Understanding these aspects is vital for biodiversity conservation and environmental management.

Applications and Limitations of Vertebrates vs Invertebrates Charts

Applications

- Educational tools for biology courses
- Reference guides for taxonomy and identification
- Visual aids in ecological research
- Conservation planning and biodiversity assessments

Limitations

- Oversimplification of complex relationships
- Variability within groups that may not be fully represented
- Evolutionary nuances not captured in static charts

Therefore, while invaluable, these charts should be complemented with detailed descriptions and phylogenetic data for comprehensive understanding.

Conclusion: The Significance of the Vertebrates vs Invertebrates Chart in Scientific Discourse

The vertebrates vs invertebrates chart remains a fundamental resource in biological sciences, encapsulating the core differences and similarities that define animal diversity. It aids in education, research, conservation, and appreciation of the complexity of life on Earth. Recognizing the evolutionary, structural, and ecological nuances illustrated by these charts fosters a deeper understanding of biological principles and emphasizes the importance of preserving this incredible diversity.

As scientific techniques advance?particularly in genomics and phylogenetics?these charts will continue to evolve, integrating new data and refining our comprehension of the animal kingdom's evolutionary tapestry. Ultimately, they serve as vital tools that bridge the gap between complex biological data and accessible knowledge, promoting curiosity and discovery in the natural sciences.

QuestionAnswer What is the main difference between vertebrates and invertebrates? The main difference is that vertebrates have a backbone or spinal column, whereas invertebrates do not have a backbone. Can you name some common examples of vertebrates? Yes, common examples include mammals (like humans and dogs), birds, fish, reptiles, and amphibians. What are typical characteristics of invertebrates? Invertebrates typically lack a backbone, have an exoskeleton or no skeleton, and often have diverse body structures and sizes. Which group is more numerous: vertebrates or invertebrates? Invertebrates are far more numerous, making up about 97% of all animal species, while vertebrates constitute about 3%. How do the nervous systems of vertebrates and invertebrates differ? Vertebrates generally have a well-developed spinal cord and brain, while invertebrates may have simpler nerve nets or ganglia without a central brain. Are all invertebrates aquatic? No, invertebrates are found in both aquatic environments (like fish and mollusks) and terrestrial habitats (like insects and arachnids). What role do invertebrates play in ecosystems? Invertebrates play essential roles such as pollination, decomposition, serving as food for other animals, and maintaining ecological balance. How does the chart help in understanding animal classification? The chart visually highlights key differences and similarities between vertebrates and invertebrates, aiding in quick comparison and understanding of animal diversity. Why is it important to study both vertebrates and invertebrates? Studying both helps us understand the diversity of life, evolutionary relationships, and the importance of different animals in ecosystems and human life.

Related keywords: vertebrates, invertebrates, animal classification, zoology, animal groups, biological taxonomy, chordates, exoskeletons, animal diversity, evolutionary traits

Vertebrates And Invertebrates Chart For Third Grade

Vertebrates and invertebrates chart for third grade is a helpful resource for young students to understand the basic differences between some of the most common animals in our world. Learning about vertebrates and invertebrates can be both fun and educational, as it introduces children to the diversity of life and how animals are classified based on their body structures. This article will guide third graders through a detailed overview of vertebrates and invertebrates, explain their characteristics, and provide an easy-to-understand chart to help students visualize these animal groups.

Understanding Vertebrates and Invertebrates

What Are Vertebrates?

Vertebrates are animals that have a backbone or spinal column. This backbone is part of their

internal skeleton, called the vertebral column. Vertebrates belong to a large group called chordates, and they are known for their complex body structures, which include a backbone, a skull to protect their brain, and a well-developed nervous system.

Characteristics of Vertebrates

- Have a backbone or spine
- Possess a skull that protects the brain
- Have an internal skeleton (endoskeleton)
- Are usually larger and more complex than invertebrates
- Have a closed circulatory system (blood circulation within vessels)
- Are warm-blooded or cold-blooded depending on the group

Examples of Vertebrates

- Fish
- Amphibians (like frogs and salamanders)
- Reptiles (like snakes and lizards)
- Birds (like eagles and sparrows)
- Mammals (like humans, dogs, and whales)

Understanding Invertebrates

What Are Invertebrates?

Invertebrates are animals that do not have a backbone. They make up the largest group of animals on Earth, and they come in many shapes and sizes. Invertebrates include creatures like insects, mollusks, worms, and many others. Despite lacking a backbone, many invertebrates have other body parts that help them move, protect themselves, and find food.

Characteristics of Invertebrates

- No backbone or spinal column
- Body structures can vary widely (soft, hard, segmented)
- Many have exoskeletons (hard outer shells)
- Reproduce in various ways (some lay eggs, some give birth)
- Most are smaller than vertebrates, but some are quite large (like giant squid)

Examples of Invertebrates

- Insects (beetles, butterflies, ants)
- Mollusks (clams, snails, octopuses)
- Worms (earthworms, flatworms)
- Jellyfish
- Sponges
- Cnidarians

Comparing Vertebrates and Invertebrates

Key Differences

To help third graders easily differentiate between these two groups, here?s a simple comparison:

- **Backbone:** Present in vertebrates; absent in invertebrates
- **Body Structure:** More complex in vertebrates, often with bones and internal organs; simpler in invertebrates, often with external shells or soft bodies
- **Size:** Vertebrates tend to be larger; many invertebrates are small, but some are very large
- **Examples:** Fish, birds, mammals vs. insects, mollusks, worms
- **Movement:** Many vertebrates walk, run, or fly; invertebrates move in various ways, such as crawling, slithering, or swimming

Why Is This Important?

Knowing the difference between vertebrates and invertebrates helps us understand the animal kingdom better. It also helps scientists and students classify animals more easily, learn about their habitats, and understand how they survive.

Vertebrates and Invertebrates Chart for Third Grade

Below is a simple chart to help third graders visualize the differences and examples of vertebrates and invertebrates:
FeatureVertebratesInvertebratesBackboneYesNoBody StructureComplex with bones and internal organsVaries; often soft or with external shellsSizeUsually largerSmall to very large (like squid)ExamplesFish, birds, mammals, amphibians, reptilesInsects, mollusks, worms, jellyfishMovementWalking, flying, swimmingCrawling, slithering, swimming

Fun Facts About Vertebrates and Invertebrates

- Did you know that there are more invertebrate species than vertebrate species? Insects alone make up over a million species!
- Some invertebrates, like the octopus, are very intelligent and can solve puzzles!
- Whales are the largest vertebrates on Earth, and they are mammals that live in the ocean.
- The giant squid, an invertebrate, can grow up to 43 feet long!
- Birds are the only animals with feathers that can fly.

Why Learning About Vertebrates and Invertebrates Is Fun and Important

Understanding the differences between vertebrates and invertebrates helps children appreciate the diversity of life on Earth. It encourages curiosity about animals, their habitats, and how they survive. Plus, it can inspire young students to explore nature, go on field trips, or even consider careers in science and wildlife conservation.

Tips for Using the Chart in the Classroom

- Have students fill in their own examples of vertebrates and invertebrates
- Use pictures and models to make the chart more engaging
- Organize a fun animal classification activity based on the chart
- Encourage students to observe animals in their environment and classify them as vertebrates or invertebrates

Conclusion

Learning about vertebrates and invertebrates is an exciting part of third-grade science. With a clear understanding and a helpful chart, students can easily remember key differences and examples of these animal groups. Whether it?s a fish swimming in the pond or an insect buzzing in the garden, every animal has a special place in our world. Keep exploring, asking questions, and discovering the amazing diversity of life around us!

Vertebrates and Invertebrates Chart for Third Grade: A Complete Guide to Understanding Animal Diversity

When it comes to learning about animals, the vertebrates and invertebrates chart for third grade is an excellent educational resource that simplifies complex biological concepts into easy-to-understand visuals. This chart serves as a foundational tool for young learners to grasp the fundamental differences between these two major groups of animals, their characteristics, and their diversity. Designed specifically for third graders, it combines colorful illustrations, clear labels, and straightforward information to make learning engaging and accessible.

Understanding the Basics: What Are Vertebrates and Invertebrates?

Before diving into the chart's details, it?s essential to understand the core concepts of vertebrates and invertebrates.

What Are Vertebrates?

Vertebrates are animals that have a backbone or spinal column. They are part of the phylum Chordata and include some of the most familiar animals like mammals, birds, fish, reptiles, and amphibians. Vertebrates tend to have complex body structures, internal skeletons, and advanced nervous systems.

What Are Invertebrates?

In contrast, invertebrates are animals that do not have a backbone. They make up the majority of animal species on Earth and include insects, arachnids, mollusks, worms, and many others. Invertebrates often have simpler body structures but are incredibly diverse in form and function.

The Significance of the Chart in Third Grade Education

The vertebrates and invertebrates chart for third grade is an educational tool that offers numerous benefits:

- Visual Learning: Children often learn best through images, and the chart provides colorful pictures that help them identify animals easily.
- Simplified Information: The chart distills complex biological classifications into simple facts suitable for third graders.
- Memory Aid: Visuals combined with brief facts help students remember key differences.
- Stimulates Curiosity: Engages students with questions and facts that encourage further exploration.
- Supports Curriculum Goals: Complements science standards by providing a clear overview of animal classification.

Features of the Vertebrates and Invertebrates Chart

The chart typically features several key components designed to make learning interactive and comprehensive.

Colorful Illustrations

Bright, detailed drawings of various animals such as lions, fish, insects, and mollusks help students visualize each group.

Classification Sections

The chart divides animals into two main categories:

- Vertebrates
- Invertebrates

Each category is further subdivided into classes or groups, with examples provided.

Key Characteristics

Brief descriptions highlight features such as:

- Presence or absence of a backbone
- Types of skeletons (internal or external)
- Body coverings (fur, feathers, shells, skin)
- Reproductive methods

Comparison Tables

Some charts include side-by-side comparisons to emphasize differences, like:

- Number of species
- Body structures
- Habitats

Deep Dive into Vertebrates

Vertebrates are a fascinating group with diverse members. The chart emphasizes their defining features and classifications.

Major Groups of Vertebrates

The chart typically categorizes vertebrates into five main groups:

- Mammals
- Birds
- Fish
- Reptiles
- Amphibians

Features of Vertebrates

Some notable features include:

- Backbone or spinal column
- Endoskeleton made of bone or cartilage
- Complex nervous system
- Usually have a circulatory system with a heart
- Body covered with skin, fur, feathers, or scales

Examples and Illustrations

- Mammals: Dog, Human, Whale
- Birds: Eagle, Sparrow, Penguin
- Fish: Salmon, Shark
- Reptiles: Snake, Turtle, Crocodile
- Amphibians: Frog, Salamander

Pros and Features

- Adapted to a variety of habitats
- Have complex behaviors
- Many are warm-blooded or cold-blooded depending on the group

Challenges for Learners

- Understanding the internal skeletal differences
- Memorizing the variety of animals within each group

In-Depth Look at Invertebrates

Invertebrates showcase an incredible diversity of life forms, and the chart helps students appreciate their importance.

Major Groups of Invertebrates

Commonly listed groups include:

- Insects
- Arachnids
- Mollusks
- Worms
- Cnidarians (like jellyfish)
- Echinoderms (like starfish)

Features of Invertebrates

- Lack a backbone
- Often have an exoskeleton or soft bodies
- May have external or internal skeletons
- Reproduce in various ways, including laying eggs or live births

Examples and Illustrations

- Insects: Butterfly, Ant, Beetle
- Arachnids: Spider, Scorpion
- Mollusks: Snail, Octopus
- Worms: Earthworm, Tapeworm
- Jellyfish and Starfish as representatives of cnidarians and echinoderms

Pros and Features

- Many can survive in extreme environments
- Essential for ecological balance (pollination, decomposition)
- Exhibit remarkable adaptability

Challenges for Learners

- Understanding their varied body structures
- Recognizing the importance of invertebrates despite their size or simplicity

Why Is the Chart a Valuable Learning Tool?

The vertebrates and invertebrates chart for third grade is more than just an informational graphic. It?s an interactive, engaging way for children to connect with the natural world. Here?s why it?s valuable:

- Encourages Observation Skills: Students learn to identify animals based on physical features.
- Builds Classification Skills: Helps children understand how scientists group animals based on traits.
- Fosters Appreciation for Biodiversity: Highlights the vast variety of life forms on Earth.
- Supports Science Curriculum: Reinforces lessons about animal habitats, body parts, and adaptations.

Using the Chart Effectively in the Classroom

To maximize the educational benefits, teachers and parents can incorporate the chart into various activities:

- Animal Identification Games: Using the chart to quiz students.
- Creative Projects: Drawing or creating models of animals from the chart.
- Discussion Starters: Asking questions about animal features and habitats.
- Field Trips: Visiting zoos or aquariums with the chart as a reference.

Conclusion

The vertebrates and invertebrates chart for third grade is an invaluable resource that simplifies the complex world of animals for young learners. By providing clear visuals, concise facts, and a logical classification system, it helps children appreciate the diversity and complexity of life on Earth. Using this chart, students not only learn to distinguish animals based on their physical features but also develop curiosity and respect for the natural world. As they grow, this foundational knowledge will inspire further exploration into biology, ecology, and the importance of conserving animal species worldwide.

Whether used in classroom lessons, homeschooling, or self-study, this chart serves as a stepping stone toward a lifelong interest in the animal kingdom. Its engaging design and educational content make it an essential tool for nurturing the next generation of scientists, conservationists, and animal

lovers.

QuestionAnswer What is the main difference between vertebrates and invertebrates? Vertebrates have a backbone or spine, while invertebrates do not have a backbone. Can you name some animals that are vertebrates? Sure! Examples of vertebrates include dogs, cats, birds, fish, and humans. What are some common invertebrates? Common invertebrates are insects like butterflies and beetles, worms, jellyfish, and octopuses. Why is it important to learn about vertebrates and invertebrates? Learning about them helps us understand the different animals in the world and how they live and survive. Which group, vertebrates or invertebrates, has more species? Invertebrates have many more species than vertebrates, making up most of the animal kingdom. What are some characteristics of invertebrates? Invertebrates usually do not have bones or a backbone and may have soft bodies or shells. How can you tell if an animal is a vertebrate? You can tell if an animal is a vertebrate if it has a backbone or spine inside its body. Is a frog a vertebrate or an invertebrate? A frog is a vertebrate because it has a backbone.

Related keywords: vertebrates, invertebrates, chart, third grade, animals, biology, classification, animal groups, educational chart, learning tools

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