

FOSSILS



See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.



1. **DESCRIPTION:** Teams identify and classify fossils and demonstrate their knowledge of ancient life by completing tasks related to interpretation of past environments and ecosystems, adaptations and evolutionary relationships, and use of fossils in dating and correlating rock units.

A TEAM OF UP TO: 2

APPROXIMATE TIME: 50 minutes

2. **EVENT PARAMETERS:**

- Each team may bring one magnifying glass, the *Science Olympiad Official Fossil List* and one 2" or smaller three-ring binder, as measured by the interior diameter of the rings, containing information in any form and from any source. Sheet protectors, lamination, tabs and labels are permitted.
- If the event features a rotation through a series of laboratory stations where the participants interact with samples, specimens, or displays; no material may be removed from the binder.

3. **THE COMPETITION:**

- Participants will move from station to station, with the length of time at each station predetermined and announced by the Event Supervisor.
- Participants may not return to stations but may continue to work on their responses throughout.
- Stations will feature task-oriented activities emphasizing application of paleontological concepts.
- Identification will be limited to specimens on the *Science Olympiad Official Fossil List*, but other samples may be used to illustrate key concepts.
- Questions will be chosen from the following topics:
 - Identification of all fossil specimens on the *Science Olympiad Official Fossil List*
 - Taxonomic classification restricted to the hierarchy on the *Science Olympiad Official Fossil List*
 - Conditions required for a plant or an animal to become fossilized
 - Common modes of preservation: petrification/petrifaction (e.g., permineralization & mineral replacement including silicification and pyritization), cast, external vs. internal molds (steinkerns), imprints, carbonization, unaltered remains
 - Uncommon modes of preservation: encasement in amber, mummification, freezing, tar
 - Relative dating: law of superposition, original horizontality, cross-cutting relationships, unconformities
 - Absolute dating: radiometric dating (i.e., Carbon 14 dating), including half-life, radioactive isotopes used, and use of igneous rocks and volcanic ash layers in absolute dating
 - The Geologic Time Scale, its organization, major events, the 5 major mass extinctions, and the Pleistocene-Holocene extinction of megafauna. An official *Science Olympiad Geologic Time Scale* is posted at soinc.org & should be used for all competitions
 - Index Fossils: characteristics and use in determining the age of rocks & geologic formations
 - Fossil-bearing sedimentary rocks: limestone, shale, sandstone, coquina, chert
 - Modes of life: filter feeder, predator, scavenger, deposit feeder, benthic, pelagic
 - Environments: shallow marine, reef, lagoon, deep marine, terrestrial, fresh water
 - Mineral and organic components of exoskeletons, shells, and bones/teeth (e.g., calcite, aragonite, silica, chitin, biological apatite)
 - Adaptations and morphologic features of major fossil groups
 - Important paleontological discoveries (i.e., non-avian dinosaurs with feathers; transitional species such as *Tiktaalik* and *Archaeopteryx*)
 - Lagerstätten* (conservation and concentration) and their significance, limited to: Burgess Shale, Beecher's Trilobite Bed, Mazon Creek, Ghost Ranch, Solnhofen Limestone, Yixian Formation (Liaoning), Green River Formation, and La Brea Tar Pits
 - Fossils as evidence for evolutionary trends and patterns such as morphological adaptations within groups, major evolutionary events and transitions (e.g., Cambrian Explosion, Mesozoic Marine Revolution, fish to tetrapods, dinosaurs to birds, whales, horses)
 - Trace fossils (ichnofossils) including, but not limited to trails, trackways, borings, burrows, tubes, predation marks, repair scars, and coprolites
 - Stromatolites, how they form, and their role in the history of life and development of Earth's atmosphere

FOSSILS (CONT.)



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4. **SAMPLE QUESTIONS/TASKS:**

- a. Identify each fossil, record its mode of preservation, the type of rock the sample is embedded in, and the geologic period it represents.
- b. List samples in order from oldest to most recent.
- c. Based on the fossil and rock associations, determine the environment in which the organism lived.
- d. The fossils illustrated were discovered in the Solnhofen Limestone, a unique Lagerstätten in Germany. What geological period is indicated based on the specimens in this limestone?
- e. How can the occurrence of both marine and terrestrial animals in the Solnhofen Limestone be explained?
- f. Describe the evolutionary relationships between the organisms illustrated on the family tree (cladogram/phylogenetic tree).
- g. Construct a range chart and determine the age of the fossil assemblage.

5. **SCORING:**

- a. High score wins. Points will be awarded for the quality and accuracy of responses.
- b. Ties will be broken by the accuracy and/or quality of responses to several pre-identified questions.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries the Fossils CD, the Bio/Earth Science CD, and the *Smithsonian Handbooks: Fossils*; other resources are on the event page at soinc.org.

FOSSIL LIST

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.**KINGDOM PROTOZOA****Phylum Foraminifera (Forams) ***

- Order Fusulinida (Fusulinids)*
- Order Rotaliida*
- Genus *Nummulites**

KINGDOM ANIMALIA**SPONGES (Phylum Porifera)**

- Genus *Astraeospongia* (calcareous sponge)
- Genus *Hydnoceras* (glass sponge)*

BRYOZOANS (Phylum Bryozoa)

- (Growth forms: branching, massive, fenestrate)
- Genus *Archimedes*
- Genus *Rhombopora*

GRAPTOLITES (Phylum Hemichordata)*

- Order Dendroidea (benthic graptolites)
- Order Graptoloidea (planktic graptolites)

CORALS (Phylum Cnidaria)

- Order Tabulata (tabulate corals)
 - Genus *Favosites*
 - Genus *Halysites**
- Order Rugosa (rugose corals)
 - Genus *Heliophyllum* (horn coral)
 - Genus *Hexagonaria*
- Order Scleractinia (stony corals)
 - Genus *Septastrea*

ARTHROPODS (Phylum Arthropoda)

- Subphylum Crustacea (shrimp, lobster, crabs, barnacles, ostracods)*
- Subphylum Chelicerata
 - Order Eurypterida (Eurypterids)
- Class Insecta (Insects)
- Class Trilobita (Trilobites)
 - Genus *Cryptolithus*
 - Genus *Calymene*
 - Genus *Elrathia*
 - Genus *Isotelus**
 - Genus *Eldredgeops* (formerly *Phacops*)

BRACHIOPODS (Phylum Brachiopoda)

- Class Inarticulata
 - Genus *Lingula*
- Class Articulata
 - Genus *Atrypa*
 - Genus *Composita*
 - Genus *Juresania**
 - Genus *Leptaena*
 - Genus *Mucrospirifer*
 - Genus *Platystrophia*
 - Genus *Rafinesquina*
 - Order Rhynchonellida

MOLLUSKS (Phylum Mollusca)

- Class Bivalvia (clams, oysters, mussels)
 - Genus *Exogyra*
 - Genus *Gryphaea*
 - Genus *Pecten*
 - Genus *Glycymeris*
 - Genus *Astarte*
 - Genus *Nucula*
- Class Cephalopoda
 - Order Goniatitida (goniatites)*
 - Order Ceratitida (ceratites)*
 - Order Ammonitida (ammonites)
 - Genus *Baculites*
 - Genus *Dactylioceras*
 - Order Belemnitida (Belemnites)
 - Genus *Belemnitella*
 - Order Nautilida (Chambered Nautilus)
 - Order Orthocerida ("Orthoceras")
- Class Gastropoda (Snails)
 - Genus *Conus*
 - Genus *Cypraea*
 - Genus *Platyceras*
 - Genus *Turritella*
 - Genus *Worthenia*

ECHINODERMS (Phylum Echinodermata)

- Class Asteroidea (Starfish)*
- Class Blastoidea
 - Genus *Pentremites*
- Class Crinoidea (stems, columns, calyxes)
- Class Echinoidea (regular or irregular echinoids including sea urchins, sand dollars and heart urchins)
- Class Ophiuroidea (brittle stars)*

VERTEBRATES (Phylum Chordata)

- Superclass Agnatha (Jawless Fish) (Ostracoderms)*
- Class Placodermi (Armored Jawed Fish)
 - Genus *Bothriolepis*
 - Genus *Dunkleosteus*
- Class Chondrichthyes (Cartilaginous Fish)
 - Superorder Selachimorpha (Sharks)
 - Genus *Otodus*
 - Genus *Carcharocles* (formerly *Carcharodon*)
 - Species *C. megalodon*
 - Superorder Batoidea (Rays)*
- Superclass Osteichthyes (Bony Fish)
 - Class Actinopterygii (ray-finned)
 - Genus *Knightsia*
 - Genus *Xiphactinus**
 - Class Sarcopterygii (lobe-finned)
 - Genus *Eusthenopteron*
 - Genus *Latimeria* (Coelacanth)
 - Genus *Tiktaalik*

Note: Taxa marked by an asterisk (*) are for State and National Tournaments only

FOSSIL LIST (CONT.)

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

Class Amphibia (Amphibians)

Genus *Acanthostega*Genus *Eryops*Genus *Diplocaulus*

Class Reptilia (Reptiles)

Order Crocodylia (crocodiles)*

Order Testudines (turtles)*

Order Ichthyosauria (Ichthyosaurs)

Order Squamata

Family Mosasauridae (Mosasaurs)

Order Plesiosauria (Plesiosaurs & Pliosaurus)

Order Pterosauria (Pterosaurs)

Clade Dinosauria (Dinosaurs)

Order Saurischia (lizard-hipped)

Suborder Theropoda

Genus *Allosaurus*Genus *Coelophysis*Genus *Dilophosaurus*Genus *Spinosaurus**Genus *Tyrannosaurus*Genus *Velociraptor*

Suborder Sauropodomorpha

Genus *Brachiosaurus*Genus *Diplodocus*Genus *Patagotitan**Genus *Plateosaurus*

Order Ornithischia (bird-hipped)

Infraorder Ankylosauria

Genus *Ankylosaurus*

Infraorder Ceratopsia

Genus *Triceratops*Genus *Protoceratops**

Infraorder Ornithopoda

Genus *Iguanodon*Genus *Parasaurolophus*Genus *Maiasaura*

Infraorder Pachycephalosauria

Genus *Dracorex*

Infraorder Stegosauria

Genus *Stegosaurus*

Class Aves (Birds)

Genus *Archaeopteryx*Genus *Titanis* (Terror Bird)Genus *Ichthyornis**

Clade Synapsida

Mammal-like Reptiles

Genus *Dimetrodon* (pelycosaurs)Genus *Lystrosaurus* (therapsids)

Class Mammalia (Mammals)

Genus *Basilosaurus* (prehistoric whale)Genus *Equus* (modern horse)Genus *Australopithecus* (hominin)*Genus *Homo* (hominin)Species *H. neanderthalensis*Species *H. erectus**Species *H. sapiens*Genus *Mammut* (Mastodon)Genus *Mammuthus* (Mammoth)Species *M. primigenius***(Woolly Mammoth)**Genus *Megacerops* (Brontothere)Genus *Mesohippus* (three-toed horse)Genus *Smilodon* (saber-toothed cat)**KINGDOM PLANTAE****FLOWERING PLANTS (Phylum Anthophyta)**Genus *Acer* (Maple)Genus *Populus* (Aspen & Poplar)Genus *Platanus* (Sycamore)**GINKGOS (Phylum Ginkgophyta)**Genus *Ginkgo***CLUB MOSSES (Phylum Lycopodiophyta)**Genus *Lepidodendron* (scale tree)**CONIFERS (Phylum Pinophyta)**Genus *Metasequoia***HORSETAILS (Phylum Sphenophyta)**Genus *Calamites* (form leaf genus: *Annularia*)**SEED FERNS (Phylum Pteridospermatophyta)**Genus *Glossopteris***TRUE FERNS (Phylum Pteridophyta)**Genus *Psaronius* (form leaf genus: *Pecopteris*)**ADDITIONAL EARTH MATERIALS**

Trace Fossils

Trails, Tracks, Trackways,

Borings, Burrows, Tubes

Predation marks, Repair scars

Coprolites

Stromatolites

Amber/copal

Petrified wood

Sedimentary Rocks

Coquina

Limestone (Chalk/Fossil limestone)

Sandstone

Shale

Chert

Note: Taxa marked by an asterisk (*) are for State and National Tournaments only

GENERAL RULES

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

GENERAL RULES, CODE OF ETHICS, AND SPIRIT OF THE PROBLEM

The goal of competition is to give one's best effort while displaying honesty, integrity, and good sportsmanship. Everyone is expected to display courtesy and respect - see Science Olympiad Pledges. Teams are expected to make an honest effort to follow the rules and the spirit of the problem (not interpret the rules so they have an unfair advantage). Failure by a participant, coach, or guest to abide by these codes, accepted safety procedures, or rules below, may result in an assessment of penalty points or, in rare cases, disqualification by the tournament director from the event, the tournament, or future tournaments.

1. Actions and items (e.g., tools, notes, resources, supplies, electronics, etc.) are permitted, unless they are explicitly excluded in the rules, are unsafe, or violate the spirit of the problem.
2. While competing in an event, participants may not leave without the event supervisor's approval and must not receive any external assistance. All electronic devices capable of external communication as well as calculator applications on multipurpose devices (e.g., laptop, phone, tablet) are not permitted unless expressly permitted in the event rule or by an event supervisor. Cell phones, if not permitted, must be turned off. At the discretion of the event supervisor, participants may be required to place their cell phones in a designated location.
3. Participants, coaches and other adults are responsible for ensuring that any applicable school or Science Olympiad policy, law, or regulation is not broken. All Science Olympiad content such as policies, requirements, clarifications/changes and FAQs on www.soinc.org must be treated as if it were included in the printed rules.
4. All pre-built devices presented for judging must be constructed, impounded, and operated by one or more of the 15 current team members unless stated otherwise in the rules. If a device has been removed from the event area, appeals related to that device will not be considered.
5. Officials are encouraged to apply the least restrictive penalty for rules infractions - see examples in the Scoring Guidelines. Event supervisors must provide prompt notification of any penalty, disqualification or tier ranking.
6. State and regional tournament directors must notify teams of any site-dependent rule or other rule modification with as much notice as possible, ideally at least 30 days prior to the tournament.

COVID-19 PANDEMIC RULES MODIFICATIONS

The COVID-19 pandemic requires that some general modifications be made to the Event Rules listed in this manual in order to permit Science Olympiad competitions to continue in a way that reflects best public health, disease prevention, and personal safety practices. The modifications listed here will be in effect for all Science Olympiad competitions, regardless of level (e.g., Invitational, Regional, State, National), or type (e.g., In-Person, Satellite SO, mini SO). As the pandemic is evolves, these modifications may be amended or rescinded according to local conditions. If changes are made, the Tournament Director for the affected tournament will make an announcement to all participating teams as soon as possible.

1. **If not already allowed, each individual participant can have a personal set of reference materials (e.g., binders, single sheets of paper), calculator, or other academic resource as specified in the specific event rule for use during the competition to facilitate social distancing, isolation, and to prevent resource sharing. Personal sets of resource materials must meet all the criteria established in the specific event rule. This does not apply to Recommended Lab Equipment for Division B or Division C Chemistry Events or tool kits for Build Events.**
2. **Given local conditions, participants may not be able to be in the same location as their partner during competition. Tournaments will allow designated partners to compete from separate locations and competing teams will only need one device for Build or Hybrid with Build Events.**
3. **At the discretion of the Tournament Director, portions of Hybrid Events containing hands-on activities as well as Build and Lab Events may be dropped from the tournament or be conducted as trial events.**
4. **At the discretion of the Tournament Director and Event Supervisors, completion time may be used as a tiebreaker for Core Knowledge and other events where a written or online test is used.**



For Event Supervisors Only - Do Not Post
CHEMISTRY RECOMMENDED LAB EQUIP.

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

Each team may bring any or all of the items listed below for use in Division C Chemistry Events requiring laboratory equipment. Teams not bringing these items will be at a disadvantage as Event Supervisors will not provide Recommended Lab Equipment. A penalty of up to 10% may be given if a team brings prohibited lab equipment to the event.

Item & Expected Use	Likely to be used in:			
	Chemistry Lab	Forensics	Environmental Chemistry	Materials Science
Box - Containing all of the kit materials	X	X	X	X
10 ml Graduated Cylinder - Measuring volumes	X		X	
25 ml Graduated Cylinder - Measuring volumes	X		X	
100 ml Graduated Cylinder - Measuring volumes	X		X	
50 ml Beakers - Doing reactions, developing chromatograms	X	X	X	X
100 ml Beakers - Doing reactions, developing chromatograms	X	X	X	X
250 ml Beakers - Doing reactions, developing chromatograms	X	X	X	X
400 ml Beakers - Doing reactions, developing chromatograms	X	X	X	X
50 ml Erlenmeyer Flasks - Doing reactions	X		X	
125 ml Erlenmeyer Flasks - Doing reactions	X		X	
250 ml Erlenmeyer Flasks - Doing reactions	X		X	
Test Tubes - Mix Chemicals, heat chemicals	X	X	X	X
Test Tube Brush - Clean Test Tubes	X	X	X	X
Test Tube Holder - Holds test tubes for heating	X	X	X	
Test Tube Rack - Hold Test Tubes	X	X	X	X
Spot Plates - For semi-micro scale reactions, testing solubility, pH	X	X	X	
Petri Dishes - Doing reactions, developing chromatograms	X	X	X	X
Slides - To put hairs, crystals, or fibers on for use with a microscope		X		
Cover Slips - To cover & prevent items from coming off slides		X		
Droppers - Add small amounts of liquids to reactions	X	X	X	X
Spatulas or spoons - Getting small amounts of solids out of containers	X	X	X	X
Metal Tongs, Forceps, or Tweezers - Holding & retrieving objects	X	X	X	X
Stirring Rods - Stirring mixtures	X	X	X	X
Thermometer - Determining the temperature of a solution	X	X	X	
pH or Litmus paper - Test acidity or alkalinity of solution	X	X	X	
Hand Lens - Magnification of small items for identification		X		
Flame Loop - For identification of ions in a compound		X		
Cobalt Blue Glass - To filter out any sodium that might contaminate flame test from hands		X		
Filter Paper - Filter solids from liquids	X		X	
Funnel - Hold Filter Paper	X		X	
9V battery - Electrolysis	X		X	X
Alligator Clip Wires - Connecting meters to metals	X		X	X
Nail - Electrolysis	X		X	X
Piece of Cu metal - Electrolysis	X		X	X
Piece of Zn metal - Electrolysis	X		X	X
Multimeter - Measuring current, voltage, and resistivity	X		X	X
9V or less Battery Conductivity Tester - Determining ionic strength of solution	X	X	X	X
Calipers-mechanical, not digital - Measuring lengths very precisely	X			X
Paper Towels - Cleaning	X	X	X	X
Pencil - Writing, Marking Chromatogram		X		
Ruler - Measuring lengths		X		
Magnets - For extraction and identification of iron filings	X	X	X	X



For Event Supervisors Only - Do Not Post CALCULATOR CLASS DESCRIPTIONS

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

The following document was prepared to offer some guidance to teams as they select calculators for use in different Science Olympiad events. By no means are the calculators listed here inclusive of all possible calculators; instead they are offered as common examples. The decisions of the event supervisors will be final.

Class I - Stand-alone non-graphing, non-programmable, non-scientific 4-function or 5-function calculators

are the most basic type of calculators and often look like the one shown to the right. These calculators are limited to the four basic mathematics functions and sometimes square roots. These calculators can often be found at dollar stores.



Class II - Stand-alone non-programmable, non-graphing calculators look like the calculator to the right or simpler. There are hundreds of calculators in this category but some common examples include: CASIO FX-260, Sharp EL-501, and TI-30X.



Class III- Stand-alone, programmable, graphing calculators and stand-alone non-graphing, programmable calculators, often look like the calculator shown on the right. Some examples are: Casio 975 0/9850/9860, HP 40/50/PRIME, and TI 83/84/89/NSPIRE/VOYAGE.

To identify a stand-alone non-graphing, programmable calculators are look for the presence of the 'EXE' button, the 'Prog' button, or a 'file' button. Examples include but are not limited to: Casio Super FXs, numerous older Casio models, and HP 35S. A calculator of this type with the buttons labeled is shown to the right.



PROG Button

EXE Button



Class IV - Calculator applications on multipurpose devices (e.g., laptop, phone, tablet, watch) are not allowed unless expressly permitted in the event rule.



EYE PROTECTION GUIDE

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

This resource was created to help teams comply with the Science Olympiad Policy on Eye Protection adopted on July 29, 2015 and posted on the Science Olympiad Website (soinc.org).

Participant/Coach Responsibilities: Participants are responsible for providing their own protective eyewear. Science Olympiad is unable to determine the degree of hazard presented by equipment, materials and devices brought by the teams. Coaches must ensure the eye protection participants bring is adequate for the hazard. All protective eyewear must bear the manufacturer's mark Z87. At a tournament, teams without adequate eye protection will be given a chance to obtain eye protection if their assigned time permits. If required by the event, participants will not be allowed to compete without adequate eye protection. This is **non-negotiable**.

Corresponding Standards: Protective eyewear used in Science Olympiad must be manufactured to meet the American National Standards Institute (ANSI) standard applicable at its time of manufacture. The current standard is ANSI/ISEA Z87.1-2015. Competitors, coaches and event supervisors are not required to acquire a copy of the standard. The information in this document is sufficient to comply with current standards. Water is not a hazardous liquid and its use does not require protective eyewear unless it is under pressure or substances that create a hazard are added.

Compliant Eyewear Categories: If an event requires eye protection, the rules will identify one of these three categories. Compliance is simple as ABC:

CATEGORY A

- Description: Non-impact protection. They provide basic particle protection only
- Corresponding ANSI designation/required marking: Z87
- Examples: Safety glasses; Safety spectacles with side shields; and Particle protection goggles (these seal tightly to the face completely around the eyes and have direct vents around the sides, consisting of several small holes or a screen that can be seen through in a straight line)

CATEGORY B

- Description: Impact protection. They provide protection from a high inertia particle hazard (high mass or velocity)
- Corresponding ANSI designation/required marking: Z87+
- Example: High impact safety goggles

CATEGORY C

- Description: Indirect vent chemical/splash protection goggles. These seal tightly to the face completely around the eyes and have indirect vents constructed so that liquids do not have a direct path into the eye (or no vents at all). If you are able to see through the vent holes from one side to the other, they are NOT indirect vents
- Corresponding ANSI designation/required marking: Z87 (followed by D3 is the most modern designation but, it is not a requirement)
- Example: Indirect vent chemical/splash protection goggles

Examples of Non-Compliant Eyewear:

- Face shields/visors are secondary protective devices and are not approved in lieu of the primary eye protection devices below regardless of the type of vents they have.
- Prescription Glasses containing safety glass should not be confused with safety spectacles. "Safety glass" indicates the glass is made to minimize shattering when it breaks. Unless these glasses bear the Z87 mark they are not approved for use.

Notes:

1. A goggle that bears the Z87+ mark and is an indirect vent chemical/splash protection goggle will qualify for all three Categories A, B & C
2. VisorGogs do not seal completely to the face, but are acceptable as indirect vent chemical/splash protection goggles