CONCEPT and SKILL ANALYSIS and ALLOCATION OF NGSS STANDARDS
MIDDLE SCHOOL (Grades 5-8)

The NGSS standards have been allocated to transferable concepts and skills embedded within comprehensive structures for each. Both comprehensive structures are organized cognitively according to generality, complexity, and abstractness, three properties that characterize intellectual growth.

BASIC CONCEPT	SUB-CONCEPT		SUB-SUB-CONCEPT
LANGUAGE OF SCIENCE A • nature of matter	ENTITY, SYSTEM, MATTER A • things and substances (intensive, extensive properties) • delineation, naming • wave as entity • system • environment, context	HIERARCHY OF MATTER A • elements, compounds, mixtures • kinetic theory of matter • Periodic table	BULK SCALE A MOLECULAR SCALE B MS-PS1-1 The composition of molecules and crystalline solids is described at the atomic scale MS-PS1-4 Temperature, state and particle motion change when thermal energy is added or removed. MS-PS1-5 Mass and number of atoms are conserved during a chemical reaction. ATOMIC SCALE C atomic structure, Bohr model NUCLEUS AND ELEMENTARY PARTICLES • Radioactivity d QUARKS AND LEPTONS e
		HIERARCHY OF LIFE A MS-LS1-1 Living things are made of cells MS-LS1-3 Organisms to organ systems to tissues.	MOLECULAR LEVEL OF LIFE a CELLULAR SCALE B • Organelles MS-LS1-2 Cell and organelle functions. (Also put under Process) TISSUE ORGAN ORGAN SYSTEM ORGANISM POPULATION COMMUNITY
	PROPERTY/MEASUREMENT A • observation, value, unit • error, accuracy • misc properties: hardness, melting/boiling T°'s, (non)-conductor MS-ESS1-3 Objects in the solar system can be compared at several scales.		SCALE/SIZE A MS-ESS2-2 Geo-science processes operate at varying time and spatial scales. NUMBER B PHASE, STRUCTURE B COMPOSITION B TEMPERATURE B DISTANCE, AREA, VOLUME C • dimensions SHAPE, ANGLE, CONFIGURATION c SPEED C LOCATION, DIRECTION, ORIENTATION c TEXTURE d HARDNESS, CLEAVAGE d POROSITY, PERMEABILITY E MASS F DENSITY, CONCENTRATION G UNIFORMITY h CHARGE, POLARITY h SOLUBILITY h

	CHANGE/ PROCESS B • change-over-time MS-ESS1-4 Rock strata are used to organize Earth's 4.6-billion year history. MS-ESS2-1 Earth's materials cycle because of energy flows that drive the process. MS-ESS2-3 Plate tectonics is evidenced by fossils and rocks, continental shapes, and seafloor structures. MS-ESS2-5 Motion and interactions of air masses cause weather changes. MS-ESS3-1 Geo-science processes distribute minerals, energy and water resources unevenly around Earth. MS-LS1-2 Cell and organelle functions. (Also put under *Hierarchy of Life → Cellular scale*.)	RATIO, PERCENTAGE A SEQUENCE of EVENTS, TIME, RATE A MS-LS1-8 Sensory receptors send messages to the brain for immediate behavior or memory storage. CYCLE B • input-output • dynamic equilibrium MS-ESS1-1 Lunar phases, eclipses of sun and moon, and the seasons are cyclic patterns. MS-ESS2-4 Water cycle. CORRELATION, CAUSALITY B • (in)dependent, controlled variable MS-ESS1-2 Gravity controls the motion of objects within galaxies and solar systems. MS-ESS2-6 Unequal heating and the Earth's rotation cause circulation patterns in the oceans and atmosphere. MS-ESS3-2 Catastrophic events can sometimes be predicted and mitigating technologies developed. GRAPH, EQUATION B

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
INTERDEPENDENCE/ ECOSYSTEM B • predator/prey • food chain/web • symbiosis: parasitism, commensalism, mutualism • natural and mechanical systems MS-LS1-4 Animal behaviors and plant structures affect reproduction MS-LS1-5 Environmental and genetic factors influence the growth of organisms. MS-LS1-6 Photosynthesis is key to the cycling of matter and flow of energy through organisms. MS-LS2-1 Resource availability affects organisms and populations in an ecosystem. MS-LS2-2 Interactions among organisms follow clear patterns across multiple ecosystems. MS-LS2-3 Matter cycles and energy flows among living and non-living parts of an ecosystem. MS-LS2-4 Changes to the physical or biological components of an ecosystem affect populations. MS-LS2-5 Solutions can be designed for maintaining biodiversity and ecosystem services. (also put *under Skills → Design*) MS-ESS3-5 Several factors have caused the rise in global temperatures.	NATURAL ENVIRONMENT A • surroundings, context • biome MS-ESS3-3 Solutions can be designed for monitoring and minimizing humans' environmental impact. (Also put under *Skills → Design*)	HABITAT, NICHE A RESOURCE, POLLUTANT A DESIGNED or CONSTRUCTED ENVIRONMENT b CONSERVATION, RESTORATION B
	DIVERSITY A • community	SPATIAL , TEMPORAL DISTRIBUTION B STATISTICAL DISTRIBUTION b • Normal (bell) distribution
	COMPLEMENTARITY B • equilibrium of flows and reservoirs MS-ESS3-4 Increased human population and consumption impact Earth's systems.	FORM AND FUNCTION A CARRYING CAPACITY (NATURAL LIMITS) A SUCCESSION, CLIMAX a CYCLE B

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
ENERGY & ENERGY RESOURCES B • energy resources and uses	ENERGY FORMS & TRANSFORMATION A • groupings: potential, mechanical • photosynthesis • metabolism/respiration MS-PS3-5 Changes in kinetic energy are caused by either energy inputs or outputs	POSITION (GRAVITATIONAL) ENERGY, KINETIC ENERGY A • mechanical energy MS-PS3-1 Kinetic energy is related to both an object's mass and speed MS-PS3-2 Potential energy changes when the arrangement of objects interacting at a distance changes
		THERMAL, CHEMICAL ENERGIES A MS-PS3-4 Thermal energy changes depend up the composition, mass and temperature change of the object
		ELASTIC ENERGY A
		WAVE ENERGY B
		ELECTRICAL-MAGNETIC ENERGY B
		NUCLEAR/MASS ENERGY B
	HEAT TRANSFER a MS-PS3-3 Solutions can be designed for optimizing thermal energy transfer. (also put under *Skills → Design*)	CONDUCTION A
		CONVECTION A
		RADIATION B
		ADVECTION b • transfer thru latent heat
	CONSERVATION OF ENERGY B	
	EFFICIENCY C	
	ENERGY FLOW, WORK C • bulk flow vs. molecular flow	
	POWER D	
	ENERGY DEGRADATION d	ENTROPY A • molecular disorder • 2nd law of thermodynamics

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
WAVES C • representation • type/media: surface, sound, light/radiation, vibration • properties: wavelength, frequency, amplitude, speed, direction, energy MS-PS4-1 Waves have unique, often inter-related properties; e.g. energy can depend on amplitude. MS-PS4-3 Wave pulses can be used to encode and transmit digital information.	PRODUCTION, ABSORPTION, PROPAGATION A • color of things and substances • transmission and capture of information/energy • transverse, longitudinal, polarized waves • perception & spectra	INTERFACE A • partial reflection, transmission, absorption MS-PS4-2 Waves are reflected, transmitted and/or absorbed when moving from one material to another.
		SUPERPOSITION, INTERFERENCE, RESONANCE B
		DOPPLER EFFECT C • shock wave, wake
	OPTICS A • focus • optical instruments	
	REFLECTION A • luster/sheen • specular, diffuse reflection • scattering	
	REFRACTION B • Snell's Law • total internal reflection	DISPERSION a
	DIFFRACTION c	
	DUALITY (WAVE-PARTICLE) a	

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
GROWTH, DEVELOPMENT C	STAGE/PHASE A • embryo, infancy, childhood, adolescence, adult, elder • life cycle	GENESIS A
		MATURATION A
		METAMORPHOSIS A • molting
		DEGENERATION, SENESCENCE a
		REGENERATION b
	DIFFERENTIATION, SPECIALIZATION B • cellular division (mitosis)	
	LINEAR, EXPONENTIAL, GEOMETRICAL INCREASE B	

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
CHEMICAL REACTION D • reactants, products • the mole • number/mass/volume stoichiometry • solutions stoichiometry MS-PS1-2 The comparison of properties before qnd after substances interact determines if a chemical reaction MS-PS1-3 Synthetic materials come from natural resources and impact society MS-PS1-6 Devices can use chemical processes to release or absorb thermal energy. MS-LS1-7 Food is re-arranged through chemical reactions that support growth or release energy	PATTERNS IN CHEMICAL REACTIONS a • synthesis/decomposition • single/dbl displacement	COMBUSTION A • reduction/oxidation
		CARBON-BASED REACTIONS B • organic reactions
		ACID/BASE, NEUTRALIZATION b
		POLYMERIZATION b • plastics • organic macro-molecules
	BONDING A • octet rule • ionic/covalent bonds • molecular structure (Lewis, VSEPR) • inter-molecular forces (dipole, hydrogen, metallic and dispersion bonds) • solvent-solute interaction	
	CHEMICAL ENERGY, THERMAL ENERGY b • thermochemistry • sensible, latent heat • ionization energy, bond energy • heat of reaction, heat of formation • activation energy, exo/endothermic reactions • Hess's Law	ENTROPY, FREE ENERGY a
	KINETICS b • catalyst	CHEMICAL EQUILIBRIUM a • Le Chatelier's principle

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
REPRODUCTION, HEREDITY D • inherited traits • dominant/recessive traits • Punnett squares • succession, pedigree	SEXUAL, ASEXUAL REPRODUCTION A • cellular reproduction MS-LS3-2 Asexual and sexual reproduction.	
	FERTILITY, FERTILIZATION a • pollination • ovulation, menstruation	
	GENETIC CODE, CODE B • genetic variation, gene/allele MS-LS3-1 Genetic changes may affect proteins which would then affect the organism.	TRANSLATION A ▪ transcription, replication ▪ RNA functions
		TRANSMISSION b
		EXPRESSION B • epigenetics
		MUTATION b • genetic drift • environment affects

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
EVOLUTION D MS-LS4-1 Fossils document the existence, diversity, extinction, and change of life forms over time MS-LS4-2 Evolutionary relationships can be inferred from comparing among modern organisms and with fossils.	SELECTION A • natural selection • sexual selection • forced selection MS-LS4-3 Patterns in embryological development across species can produce very different anatomies. MS-LS4-4 Genetic variation increases some individuals' probability of surviving and reproducing. MS-LS4-5 Technology allows humans to influence the traits inherited by organisms. MS-LS4-6 Natural selection may lead to changes in a population's traits.	VARIATION, ADAPTATION A EXTINCTION A
		SPECIATION B • convergence • co-evolution
	GENETIC EVOLUTION a	

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
MOTION and FORCES E • types of motion (ir/regular, repetitive, accelerated, etc.) • interaction • types of forces (contact, gravity, elastic, electro-magnetic, etc.) • gravity, weight, mass MS-PS2-1 Newton's Third Law can help solve problems involving two-body collisions. MS-PS2-4 Gravitational interactions are attractive and depend on the masses of the objects MS-PS2-5 Fields exist between objects exerting non-contact forces between them.	VELOCITY, DISPLACEMENT A • Displacement versus path distance • speed plus direction	FRAMES OF REFERENCE b
		SPECIAL RELATIVITY c
	FORCES, NET FORCE, NEWTON'S 1st and 3RD LAWS A • types of forces • force vector manipulation: scaled diagram, components	FRICTION A
		GRAVITY A • Universal gravitation
		ELECTROSTATIC FORCE b
		STATIC FLUID FORCES b
		DYNAMIC FLUID FORCES b • Lift, drag
		SURFACE TENSION, CAPILLARY EFFECT b
		TORQUE/MOMENTS, CENTER OF GRAVITY b • balance
		PRESSURE b • tension, compression • shear • lift • static fluid forces
		STRENGTH c • stress, strain
	FLUID FLOW a	LAMINAR FLOW, TURBULENCE A • current, streamlines
		BOUNDARY CONDITIONS b
	ACCELERATION, NEWTON'S 2ND LAW B • kinematics • linear dynamics • impulse-momentum MS-PS2-2 The change in an object's motion depends on the sum of all forces and the object's mass.	FICTITIOUS FORCE a • Accelerated frames of reference • Coriolis force
	2- & 3-DIMENSIONAL MOTION C • vectors for d, v, & a • central force, universal gravitation	PROJECTILE MOTION A
		CIRCULAR MOTION B
		HARMONIC MOTION b
	CONSERVATION OF MOMENTUM C	
	ROTATIONAL DYNAMICS d • angular motion properties	CONSERVATION OF ANGULAR MOMENTUM, ANGULAR ENERGY A
		ROLLING b
	QUANTUM MECHANICS e	

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
REGULATION (CONTROL) E	SWITCH A • trigger	
	FEEDBACK A • positive, negative feedback • connectivity	
	EQUILIBRIUM B • homeostasis • health	RESTORING MECHANISM A
		SUSTAINABILITY a
		THRESHOLD, CRITICAL MASS b • tipping point
	PERTURBATION, MALFUNCTION B • disease • abnormality	CONTAGION VECTOR A • propagation of perturbation
		EPIDEMIC a
		ADDICTION b

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
ELECTRICITY-and-MAGNETISM E • charge, polarity • conductors, insulators • attraction/repulsion • mapping elec & mag fields MS-PS2-3 Several factors affect the strength of electric and magnetic forces.	SIMPLE CIRCUIT, OHM'S LAW A • load, source/supply • current, resistance, voltage • open circuit, short circuit • alternating and direct current	
	CONSERVATION OF CURRENT, VOLTAGE b • Kirchoff's Laws • series, parallel, combination circuits	CONTROL MECHANISM a • relay, diode, transistor/gate, integrated circuit, transformer
	ELECTRIC FORCE FIELD, ELECTRIC POTENTIAL C • Coulomb's Law; Inverse square law	GAUSS'S LAW a • line of force • flux
		CAPACITANCE b
	MOTOR, GENERATOR , TRANSFORMER c	
	MAGNETIC FORCE FIELD d • Force on moving charges • Bio-Savart law	AMPERE'S LAW a
		ELECTROMAGNETIC INDUCTANCE b • Lenz's Law • magnetic flux • transformers • AC inductance
		FARADAY'S LAW c • (Self-) inductance
		LR, LC, LRC CIRCUITS d
		MAXWELL'S EQUATIONS d

BASIC CONCEPT	SUB-CONCEPT	SUB-SUB-CONCEPT
BEHAVIOR E • stimulus-response • classical, operant conditioning • survival, self-interest, cooperation • nature vs. nurture	INSTINCT A	MATING A • female choice
		AGGRESSION A
	COMMUNICATION A	PERSUASION a
	LEARNING b • memory • language	COGNITION A • Accommodation, Assimilation, Adaptation • Thinking and reasoning
		KNOWLEDGE TRANSFER B • higher-order thinking • problem solving, decision making
		MOTIVATION, EMOTION b • curiosity • hierarchy of needs
		COMPETENCE, INTELLIGENCE c
	PERSONALITY b	ALTRUISM b • reciprocity
	STATES OF CONSCIOUSNESS c • sleep and dreams • hypnosis, meditation • drug induced	

TRANSFERABLE SKILLS FOR SCIENCE, TECHNOLOGY, ENGINEERING, AND DESIGN.

MAJOR CATEGORY	SUB-CATEGORY	SUB-SUB-CATEGORY
EXPERIMENTAL DESIGN / INQUIRY	QUESTION, HYPOTHESIS, PURPOSE	INDEPENDENT, DEPENDENT, CONTROLLED VARIABLES
	PROCEDURE, METHOD	OBSERVATION
		TRIAL AND ERROR
		CONTROLLED EXPERIMENT
		SURVEY
		PRIMARY SOURCE • diary & journals, interview, letter, periodical of time, oral tradition, official records.
		SECONDARY SOURCE • texts, reference books, author commentary, library/internet research.
	RESULTS, DATA, OBSERVATIONS	
	ANALYSIS, CONCLUSION	ERROR, VALIDITY, RELIABILITY
LAB SAFETY		
INFERENTIAL & PROCEDURAL PROBLEM SOLVING	SEQUENCE, COORDINATION • dating, timelines	
	AND, OR	
	IF…THEN	
THE DESIGN PROCESS MS-PS3-3 Solutions can be designed for optimizing thermal energy transfer. (also put under *Energy → Heat transfer*) MS-LS2-5 Solutions can be designed for maintaining biodiversity and ecosystem services. (also put under *Interdependence*) MS-ESS3-3 Solutions can be designed for monitoring and minimizing humans' environmental impact. (Also put under *Interdependence → Natural environment)*	IDENTIFY PROBLEM/GOAL • divide into smaller components	CRITERIA, CONSTRAINTS MS-ETS1-1 Criteria and constraints of a design must be defined precisely to ensure success.
		RESOURCES, MATERIALS
	GATHER INFORMATION • evidence	KNOWLEDGE AND SKILL REQUIREMENTS
	DEVELOP MULTIPLE OPTIONS	
	SELECT, REFINE, DESIGN a SOLUTION	
	CONSTRUCT SOLUTION or PROTOTYPE MS-ETS1-3 Optimum designs incorporate the best of multiple proto-types.	
	EVALUATE SOLUTION MS-ETS1-2 Design solutions are evaluated systematically on the criteria and constraints. MS-ETS1-4 Data from iterative testing can lead to optimum designs.	COSTS, BENEFITS, TRADE-OFFS EFFICIENCY, EFFECTIVENESS
	COMMUNICATE SOLUTION	
	RE-DESIGN SOLUTION	

MAJOR CATEGORY	SUB-CATEGORY	SUB-SUB-CATEGORY
MODELING picturing, 3-D modeling faithfulness, accuracy, precision Perspective, labeling, scaling.	MAPPING • incl. topographical, political, social, resource, climatic	
	GRAPHIC ORGANIZERS • diagram, flow chart, web, concept map	
	GRAPHIC DISPLAY • pie, bar, line graphs	
MATHEMATICAL MANIPULATION	BASIC OPERATIONS • Add, subtract, multiply, divide	
	UNIT CONVERSION	
	ALGEBRAIC MANIPULATION	
	GEOMETRY	
	VECTORS, TRIGONOMETRY	
	DIFFERENTIALS, INTEGRALS	
	MISC. MATH SKILLS	

