



APPLIED SCIENCE FOR
RISK-BASED DECISIONS

WELCOME...to the Hull Risk Analysis Center.

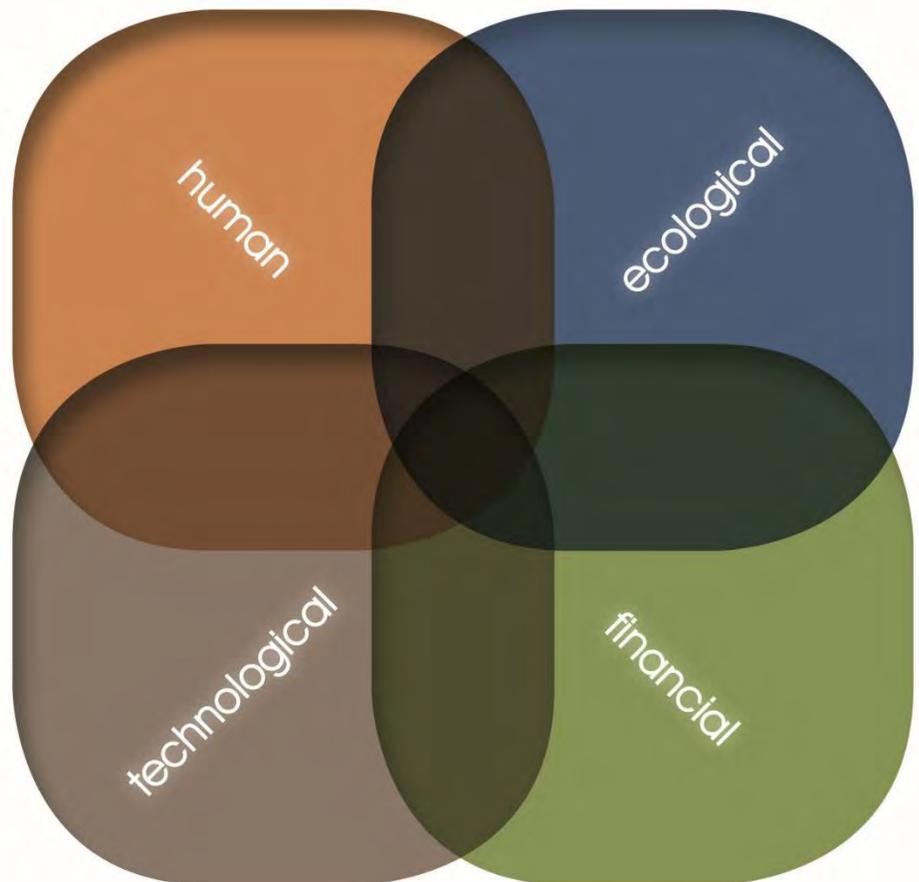
The Hull Risk Analysis Center (HullRAC) is a multidisciplinary center for excellence in risk analysis comprised of scientists and engineers working together to analyze human, ecological, technological, and financial risks. The HullRAC team includes highly-experienced, credentialed, and recognized professionals in:

- Human Health Risk Assessment,
- Exposure Assessment,
- Environmental Fate and Transport Modeling,
- Toxicology and Pharmacology,
- *In vivo* and *in vitro* Bio-availability Studies,
- Radiological Risk Assessment,
- Ecological Risk Assessment,
- Risk-based Decision Analysis,
- Systems Failure and Accident Analysis,
- Analysis of Uncertainty and Variability,
- Environmental Liability Analysis (Financial Risk), and
- Risk-Based Policy Analysis.

HullRAC experts apply these methods to support real-world decisions, primarily for the private sector.

In addition, our experts have been actively involved with the development of national and state rules, standards, guidance and policies involving risk analysis, and risk-based approaches. They have provided expert reports, opinions, depositions, and testimony.

General areas of capability and experience available from the Center are outlined in the following sections.



■ HUMAN HEALTH RISK ASSESSMENT

For three decades, HullRAC experts have been developing methodologies and preparing human health risk assessments that are concise, transparent, based on the best science, and compliant with regulatory requirements and high professional standards. We have used human health risk assessment to develop standards and increase advocacy, demonstrate regulatory compliance, support informed decision-making, and to assist in litigation. The Center's capabilities and experience in human health risk assessment include:

- Risk Assessments prepared pursuant to RCRA, CERCLA, TSCA, FIFRA, REACH, DOE, DOD, Ohio VAP, Maryland VCP, Indiana RISC, New Jersey ISRA, Pennsylvania Act 2, West Virginia VRP, and New Hampshire VCP.
- Exposure Assessment, including site-specific and personal exposure factors and metrics.
- *In vivo and in vitro* Bioavailability Studies.
- Chemical fate and transport studies and modeling
- Toxicological Assessment, including development of chemical-specific reference doses.
- Development of risk-based cleanup standards for soil, water, air and sediment.
- Uncertainty and variability analysis, including Monte Carlo Analysis.
- Expert Witness Litigation Support.

As an example of our range of experience, HullRAC human health professionals have:

- Prepared hundreds of risk assessments under various State cleanup programs, RCRA hazardous waste management units, Superfund/CERCLA sites, closure under TSCA, and sites subject to Consent Orders.



- Conducted environmental fate and eco-toxicological evaluations to meet requirements under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) in the European Union, on behalf of chemical manufacturers in the United States and Europe.
- Prepared the first Steamlined Risk Evaluation (SRE) accepted by USEPA Region V as part of an Engineering Evaluation/Cost Analysis (EE/CA) for a CERCLA NPL site.
- Led the development of the risk-based generic numerical cleanup standards for soil and groundwater under the Ohio EPA Voluntary Action Program rules, including the application of Monte Carlo Analysis to account for uncertainty and state-wide variability.
- Developed risk-based sediment cleanup levels for the Port Everglades Oil Terminal (FL) and the Fields Brook Superfund Site (OH) and other high profile sites.
- Coordinated an *in vitro* and *in vivo* bioavailability study between Hull, the Ohio State University and the University of Missouri-Columbia to develop a relative bioavailability factor for the evaluation of arsenic in soil at a U.S. EPA Superfund site in Region V, which was the basis for EPA-approved site-specific reduction of arsenic uptake assumptions for an NPL site in Illinois.
- Applied the Center's expertise in chemical fate and transport to: model groundwater and air transport; evaluate the speciation, complexation and solubility of metals and metalloids; model sub-surface gas migration and building vapor intrusion; evaluate the environmental degradation of hydraulic fracturing fluid additives used for shale gas well stimulation.

■ ECOLOGICAL IMPACT AND RISK ASSESSMENT

The hallmarks of HullRAC's approach to ecological impact and risk assessment are technical accuracy in ecological assessment/delineation and comprehensive knowledge of the scientific principles behind applicable regulations and guidance, some of which we helped develop.

The Center employs staff in key disciplines including botany, wildlife biology, fisheries biology, professional wetlands scientists, hydrogeology, hydrology, fluvial geomorphology, ecology and civil engineering. Staff members serve on state and national regulatory work groups and committees to advocate good science, keep current on developing regulations, and maintain strong agency relationships. All staff are trained in current field methodologies necessary to consult on ecological impact and risk issues.

Examples of ecological impact and risk assessments performed by HullRAC experts include:

- Design and performance of hundreds of vegetation surveys, wildlife surveys, wetland delineations, and wetland and stream impact and ecological risk assessments.
- The evaluation of harmful algal blooms, including identification and isolation of the harmful algae; isolation and identification of the algal toxins; evaluation of the environmental conditions favorable for toxin production; and estimation of the toxicity of algal toxins to vertebrate and invertebrate animals.
- Preparation of ecological risk assessments at a 1,100 acre former multi-use heavy industrial site being simultaneously remedied under Ohio EPA Orders and redeveloped as a high-end residential and recreational sports-training complex, including several miles of Lake Erie coastline and several miles of high quality river flow across the property.
- Preparation of one of the first Voluntary RCRA Corrective Actions in EPA Region V, including one of the first corrective actions based solely on ecological risk assessment and a remedy designed to re-establish and protect a terrestrial and avian ecosystem.
- Evaluation of contaminant pathways and ecological risks as the basis for perennial stream remediation and restoration at contaminated sites under administrative findings and orders.
- Development of the first wetlands evaluation methods and wetland water quality standards for



Ohio and served on the Interagency Technical Committee developing Ohio's wetland water quality rules.

- Preparation of Environmental Impact Statements (EIS) under NEPA, including field studies, wetland delineation/functional assessment, threatened and endangered species surveys, floristic and faunal inventories, and vegetation and wildlife habitat assessment, assessment of construction and operation impacts to biological resources, and biological assessment of potential impacts of stream and river crossings.
- Conducting a field study to determine the effects of freshwater effluent discharge on the vegetation of a salt marsh community, including analysis of habitat preference and use by two endangered animal species.

■ RADIOLOGICAL RISK ASSESSMENT

Through a 20-year working relationship between HullRAC and Sanford Cohen and Associates (SC&A), the Center is able to offer outstanding capabilities and experience in performing assessments of human health risks from exposure to radionuclides in the environment.

SC&A has performed more than 300 radiological risk assessment studies, which either involved risk assessment as part of the study or included the gathering and/or analysis of data, mathematical models, or computer codes for use in risk assessments. These have been in support of EPA rulemaking or standard setting; waste site cleanups, including under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA); DOE environmental restoration and nuclear facility decommissioning/decontamination; Formerly Utilized Sites Remedial Action Program sites; and other remediation efforts.

Examples of radiological risk assessment projects performed by SC&A and HullRAC are:

- SC&A supported EPA during the development of the original Risk Assessment Guidance for Superfund (RAGS) manuals. For the Human Health Evaluation Manual (HHEM), Volume I of RAGS, SC&A prepared Chapter 10 of Part A: Baseline Risk Assessment, which covered radiation protection; regulation of sites contaminated with radioactivity; collection and evaluation of data relevant to technical analyses; determination of direct and indirect exposure pathways, including inhalation and food consumption; and determination of dose and risk.
- SC&A provided technical support for EPA's efforts to establish risk-based standards for the safe recycle of materials generated from the operations, decommissioning, and cleanup of federal government and NRC licensee facilities. SC&A reviewed risk analyses performed by other agencies, conducted special studies to determine normalized doses from personal devices, evaluated the impact of the proposed recycling on sensitive industries, and performed strontium-90 investigations.
- EPA revised its methodology for estimating radiogenic cancer risks and deriving radionuclide slope factors, documented in two reports prepared by SC&A. The first, *Estimating Radiogenic Cancer Risks (EPA 402-R-93-076)*, discusses the available epidemiological data and risk characterization models, as well as EPA's approach to computing radiation exposures, body burden, and human health effects. The second report, *Radiation Exposure and Risk Assessment Manual (RERAM): Development of Radionuclide Slope Factors*, presents a more detailed discussion of the derivation of



the carcinogenic slope factor values. RERAM also discusses the biological effects of ionizing radiation; epidemiological data bases; radiation dosimetry; fate and transport and risk assessment models; routes of exposure; dose-response reference doses; and EPA dosimetric models and risk calculations.

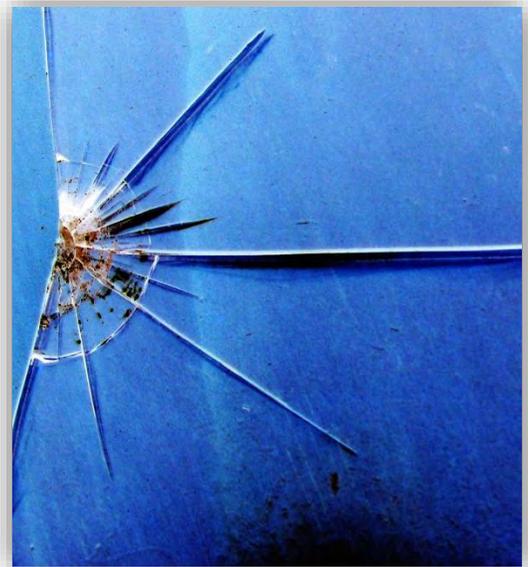
- Dr. William Rish of HullRAC and SC&A prepared a multi-year, multi-million dollar historical dose reconstruction project at Idaho National Engineering Laboratory (INEL) for the Centers for Disease Control and Prevention (CDC). The project identified, retrieved, and evaluated all documents, data, and personal accounts pertinent to the reconstruction of potential chemical and radiological doses and risks to population in the vicinity of INEL over its 40 years of operation.
- Dr. Rish (HullRAC) also prepared two program-wide guidance manuals for the USEPA Office of Radiation Programs staff on uncertainty in risk analysis and risk management – *Approach to Uncertainty in Risk Analysis (Oak Ridge National Laboratory)* and *Review of Studies Related to Uncertainty in Risk Analysis (Oak Ridge National Laboratory)*.
- As a member of the Scientific Committee of the National Council on Radiation Protection and Measurements (NCRP), Dr. Rish helped prepare *Evaluating Uncertainty in Assessment of Dose in the Absence of Site Specific Data*.
- Dr. Rish (HullRAC) and Dr. John Mauro (SC&A) prepared the analysis of uncertainties for the USEPA pathways and health effects modeling used as the basis for *Standard 40 CFR Part 191 - Environmental Radiation Protection Standards For Management And Disposal Of Spent Nuclear Fuel, High-Level And Transuranic Radioactive Waste*.

■ SYSTEMS FAILURE AND ACCIDENT ANALYSIS

HullRAC experts have the capabilities and experience to perform detailed analyses that identify possible failure mechanisms and accident scenarios for technological systems, the probability of failure and accidental events, and strategies for reducing likelihood and mitigating consequence. We accomplish this using an interdisciplinary team of engineers, risk analysts and modelers. Our experts have prepared failure and accident analyses for nuclear power systems, chemical facilities, deep injection wells systems, chemical and radiological waste containment and disposal facilities, landslides and landfills.

Some examples of systems failure and accident analyses performed by HullRAC experts include:

- Preparation of a risk analysis of deep well injection of hazardous waste for the American Chemical Council (ACC) which analyzes, using probabilistic risk assessment (PRA) methods, how underground injection technologies might fail to isolate waste from the environment, specifically from underground sources of drinking water. Both technical and human factors were evaluated. The study involved extensive workshops and interviews with industry and state and federal regulatory experts. In addition, a very large database of well accidents, failures, maintenance and repairs was developed and used.
- Analysis of the probability of accidents and/or system component failures that may result in the release of chemicals or radiation from waste handling and disposal systems at the Idaho National Engineering Laboratory (INEL).
- Detailed failure modes and effects analysis (FMEA), fault tree and event tree analysis of nuclear power plant systems, including using the results as input to the design of a safety parameter display system (SPDS) for the Waterford Nuclear Generating Station in Louisiana and the Shoreham Nuclear Power Plant in New York.
- Multiple evaluations of subsurface conditions, settlement analyses, and slope stability analyses to determine causes of shoreline, riverbank, dam, lagoon and landfill failures. Also investigation and evaluation of multiple landslide sites to determine causes and recommend corrective actions.
- As part of a large US Department of Energy effort, preparation of system reliability analysis of proposed high-level radioactive waste disposal facility, including engineering failures and human errors that may occur over a long time frame.



■ ENVIRONMENTAL LIABILITY ANALYSIS

HullRAC has a proven and extensive track record in evaluating and quantifying environmental liabilities (financial risks) for:

- Corporate reporting of Contingent Environmental Liabilities (FAS5) and Asset Retirement Obligations (FAS143);
- Merger/Acquisition due diligence and negotiation;
- Litigation support and Expert Witness services;
- Potentially Responsible Party (PRP) Allocation; and
- Insurance Settlement.



For over 25 years, HullRAC experts have been at the forefront in using decision and probability analysis to evaluate environmental liability, including decision trees and Monte Carlo Analysis.

We put environmental information and future cost estimates in a decision-making context that can be useful in negotiating deals, setting reserves and developing liability management strategies. Hull personnel have assisted attorneys and corporate environmental managers on numerous transactions, from single sites to several hundred site portfolios, nationwide and international, with liabilities ranging from tens of thousands to hundreds of millions of dollars. Some examples include:

- Assisted a major oil company in the United Kingdom to evaluate the financial risks associated with potential releases from over 500 retail gasoline stations to prioritize preventative, mitigative, and closure actions; developed decision-support software.
- Develop future remediation cost estimates in support of SEC reporting requirements and reserve determination for several corporations on an ongoing basis including annual updates.
- Prepared a business and risk evaluation for a coal mining company interested in using mine sites for ash disposal. The potential environmental liabilities of using six different mine sites for ash disposal were financially quantified. These risks were traded off against the business benefits of the venture, and strategies to manage the risks were identified.
- Assisted several large corporations in estimating environmental liabilities in support of world-wide acquisitions, as the basis for cost-sharing and indemnification agreements between the buyer and seller.
- Developed the basis for settlement amount to cover uncertain future costs in negotiations and litigation between environmental insurers and the insured.

■ BIOSKETCHES OF KEY HULLRAC STAFF

■ **WILLIAM RISH, PHD**

Human Health Risk Assessment | Environmental Liability Assessment | Uncertainty Analysis | Failure and Accident Analysis

William (Bill) directs the Hull Risk Analysis Center. He brings over 30 years experience in risk assessments, decision analyses, financial analyses, and risk-based strategies for private, public, regulatory, and legal clients.

Bill is a published expert in risk assessment and uncertainty analysis. He has been active for many years on numerous advisory committees and workgroups in the development of federal and state regulatory rules, guidance and cleanup standards. He has directed the investigation and cleanup of many complex and high-profile sites. In addition, he is a pioneer in the development and use of probabilistic methods to evaluate environmental liability and set environmental standards. He regularly assists corporations in analyzing environmental liabilities in support of strategic business needs, including Securities Exchange Commission (SEC) reporting, acquisitions and divestments, environmental property portfolio management, insurance settlements, and litigation support. Bill has a strong background in systems failure and accident analysis, including chemical and nuclear systems.

He earned his doctorate in Engineering and Public Policy and his Bachelor of Science in Metallurgy/Material Science and Public Affairs (jointly conferred) from Carnegie-Mellon University.

■ **ED PFAU, MS**

Human Health Risk Assessment | Human and Ecological Toxicology

Ed has more than 20 years experience in environmental toxicology, including 16 years in environmental risk assessment. He currently leads HullRAC's human health risk assessment team in preparing human health risk assessments for brownfields under various voluntary cleanup programs, hazardous waste management units regulated under the Resource Conservation and Recovery Act (RCRA), Superfund sites listed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and other sites subject to closure under the Toxic Substances Control Act (TSCA). These sites are located in several states (including Illinois, Indiana, Maryland, New Jersey, New Hampshire, Ohio, Pennsylvania and Virginia) and in three U.S. EPA regions. He also conducts environmental fate and eco-toxicological evaluations as part of chemical safety assessments prepared to meet requirements under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) in the European Union, on behalf of chemical manufacturers in the United States and Europe.

Before joining Hull, Ed was a senior toxicologist and risk assessor at the Ohio Environmental Protection Agency (Ohio EPA), where he was actively involved in the development of generic numerical standards, the critical review and approval of risk assessments, and the development of technical guidance. Ed also spent several years in the evaluation of harmful algal blooms. His experience included identification and isolation of the harmful algae; isolation and identification of the algal toxins; evaluation of the environmental conditions favorable for toxin production; and estimation of the toxicity of algal toxins to vertebrate and invertebrate animals.



He has a master's in Biology from Wright State University and bachelor's degrees in Biology from University of Dayton. He has served on several committees, including the ASTM E50.04 Voluntary Cleanup Task Group and the generic standards and risk assessment committee under the Ohio EPA VAP Multi-Disciplinary Board. He is an active member of the Ohio and national chapters of the Society for Risk Analysis.

■ **MONICA WILLIAMSON, MS**

Human Health Risk Assessment | Bioaccessibility/Bioavailability | Environmental Chemical Fate and Transport | Vapor Intrusion

Monica has over 10 years' experience in environmental risk assessment, with a specialization in dose assessment, chemical fate and transport and the evaluation of remedial alternatives. She prepares and reviews human health and ecological risk assessments for brownfields, hazardous waste management units, Superfund sites, and other sites where hazardous substances or petroleum pose a potential or known environmental or regulatory concern.

Monica's expertise in dose assessment includes the determination of the bioaccessibility and bioavailability of contaminants in environmental media through empirical studies and literature review, and the application of relative bioavailability factors to environmental and human health risk assessments. She has coordinated a cooperative *in vitro* and *in vivo* bioavailability study between Hull, the Ohio State University and the University of Missouri-Columbia to develop a relative bioavailability factor for the evaluation of arsenic in soil at a U.S. EPA Superfund site in Region V. She has also determined the bioaccessibility of contaminants in soils and sediments for sites being investigated in conjunction with Ohio EPA and the Great Lakes National Program Office. These estimates have been used in the qualitative evaluation of uncertainty associated with hazard and risk estimates predicated upon default dose assumptions.

Monica's expertise in chemical fate and transport includes evaluation of the behavior of inorganic chemicals in soil, and evaluation of the vapor intrusion exposure pathway. Monica's experience in the speciation, complexation and solubility of metals and metalloids in soil has been applied to the evaluation of the migration-to-groundwater (*i.e.*, leaching) exposure pathway in many environmental risk assessments. Monica's experience in the evaluation of the vapor intrusion exposure pathway includes the development of site conceptual models to determine potential receptors and the development of field sampling plans for the collection of soil, groundwater, soil gas, sub-slab vapor and indoor air. She has applied this information to the estimation of potential and actual indoor air exposures in numerous site-specific human health risk assessments, including a case-by-case determination whether environmental remediation or preventative building design are required. These assessments have been conducted in accordance with the requirements of federal and various state regulatory programs.

Monica has received a master's degree in Soil Science and a bachelor's degree in Environmental Science, each, with an emphasis in Chemistry, from the Ohio State University. She is an active member of the Ohio and national chapters of the Society for Risk Analysis.

■ **HUGH CROWELL, MS, PWS**

Ecology and Wetlands Expert | Ecological Risk Assessment

Hugh is the leader of HullRAC's Ecological Impact and Risk Assessment team. His 25-year work history includes positions in the surface water program offices of both Ohio Environmental Protection Agency (Ohio EPA) and U.S. EPA headquarters in Washington, DC.

Hugh has provided expert support for civil and criminal litigation under Clean Water Act Section 404 (surface water dredge and fill permits) and Section 402 (NPDES permits), and under Ohio regulations governing enforcement of wetland and stream water quality standards. He has also provided expert testimony on Ohio surface water regulation in surface mining zoning cases, on ecological impacts in a wind power siting case before the Ohio Power Siting Board, and on the impacts of an illegal sewage discharge on private property.

Hugh has managed ecological risk projects for brownfield, residential, commercial, industrial, county and municipal properties. He has written and negotiated numerous Clean Water Act Section 404/Section 401 and Ohio Isolated Wetlands permits, and designed stream and wetland monitoring programs. His mitigation experience includes design of wetland mitigations up to 30 acres in size. He is Rosgen-trained in stream restoration and natural channel design through Level IV, and has performed stream stability, departure assessment, and restoration design on streams up to 1.5 miles in length. He also performed ecological risk assessments under the Ohio Voluntary Action Program (VAP), the Indiana Voluntary Remediation Program, the U.S. EPA Voluntary Corrective Action Program, and Superfund.

Hugh received his Bachelor of Arts in Biology from the College of Wooster and his Master of Science in Botany/Plant Ecology from The Ohio State University. His service on water rule and policy committees included an appointment by the U.S. Army Corps of Engineers to serve as peer reviewer for the Midwest Supplement to the Wetland Delineation Manual, and participation in Ohio EPA Work Groups to review revised wetland rules and new stream mitigation rules.

■ **JOHN MAURO, PHD, CHP**

Senior VP, SC&A | Radiological Risk Assessment

John's entire career has been devoted to the assessment of the doses and potential health and environmental impacts of radiation and radioactive material in the workplace and the environment. In the first half of his career, his principal clients were nuclear utilities. In the second half of his career, his principal clients have been the Nuclear Regulatory Commission (NRC), the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency (EPA), and the National Institute of Occupational Safety and Health (NIOSH) in matters related to radiological dose and risk assessment in support of radiation protection, radiation and radioecology research, rulemaking, and policy development. John is a trusted consultant to HullRAC, as is SC&A. In 2004, John was appointed by the Governor of New Jersey as a Commissioner of Radiation Protection.

John has a Ph.D. in Health Physics from New York University Medical Center and is certified by the American Board of Health Physics.





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