SARAT CENTENARY COLLEGE

Department of Chemistry

Course Outcomes (CBCS)

Chemistry Honours

SEM-I

CC-1: Organic Chemistry – I (Basics of Organic Chemistry)

Our aim relating to this course is to provide students with a deep understanding of the structure, properties, reactions, and synthesis of organic compounds. By the end of the course, students should be able to achieve several key outcomes:

1. Fundamental Concepts: Students will understand the fundamental concepts of organic chemistry, including atomic structure, bonding, molecular geometry, and functional groups.
2. Reaction Mechanisms: Students will learn the mechanisms of organic reactions, including nucleophilic substitution, elimination, addition, and rearrangement reactions.
3. Stereochemistry: Students will understand stereochemistry, including concepts such as chirality, stereoisomers, and optical activity.
4. Spectroscopic Techniques: Students will gain knowledge of spectroscopic techniques (NMR, IR, UV-Vis, and Mass Spectrometry) and their application in determining the structure of organic compounds.
5. Laboratory Skills: Students will gain hands-on experience with common laboratory techniques in organic chemistry, including synthesis, purification, and characterization of organic compounds.
6. Safety Practices: Students will understand and adhere to safety practices and protocols in the organic chemistry laboratory.
7. Experimental Design: Students will learn to design and conduct organic synthesis experiments, including planning reaction pathways and selecting appropriate reagents and conditions.

8. Ethical Research Practices: Students will understand the ethical considerations in organic chemistry research, including issues related to data integrity, environmental impact, and responsible use of chemicals.
9. Professional Standards: Students will adhere to professional standards and best practices in the conduct of organic chemistry research and laboratory work.
10. Continued Engagement: Students will be motivated to continue learning about advances in organic chemistry, staying informed about new developments, techniques, and applications.
11. Adaptability: Students will develop the ability to adapt to new challenges and incorporate emerging knowledge and technologies into their organic chemistry practice.
12. Real-World Applications: Students will understand the applications of organic chemistry in various fields, such as pharmaceuticals, materials science, environmental science, and biotechnology.
13. Innovation and Creativity: Students will be encouraged to apply their knowledge creatively to develop new molecules, reactions, and materials with practical and commercial applications.
14. In laboratory session each student is required to carry out
    - the separation of organic compounds from their mixture based upon their solubility
    - the determination of boiling points of some organic liquid compounds.
    - the identification of some pure organic compounds using their characteristics properties.

CC-2: Physical Chemistry-I (Kinetic Theory & Gaseous State, Chemical Thermodynamics, Chemical Kinetics)

After completion of this syllabus, students will be to understand:

Kinetic Theory & Gaseous State:

1. Familiarization with various states of matter.
2. Collision theory and from collision theory calculation of collision diameter, collision number, frequency of binary collision.
3. Understanding Kinetic model of gas and its properties.
4. Maxwell distribution, mean-free path, kinetic energies.
5. Behaviour of real gases, its deviation from ideal behaviour, equation of state, isotherm, and law of corresponding states.

Chemical Thermodynamics:

1. Use of thermodynamic terminology correctly.(concept of system, variables, heat, work, internal energyand their relations).
2. Explain fundamental thermodynamic properties
3. Zeroth law and first law of thermodynamics for a closed systems and the change in energy in the closed systems via heat and work transfer
4. Learn the application of thermodynamics: Joule's experiment, Joule Thompson effects(ideal gas and van der walls gas)
5. Concept of heat of reactions and use of equations in calculations of bond energy, enthalpy of formation, combustion, etc
6. Second Law of thermodynamics and using second law of thermodynamics(Carnot cycle), calculate thermal efficiency and coefficient of performance for heat engine, refrigerators, idea about reversible and irreversible processes.
7. Idea about auxiliary state function (Gibbs free energy, Helmholtz free energy), and from this function conditions of reversible and irreversible processes.
8. Idea about different thermodynamic reactions (Maxwell relation, Gibbs-Helmholtz equation etc.)

Chemical Kinetics:

1. Understand the basics of chemical kinetics: determination of order, molecularity, integrated rate equations, half-life of a reaction,
2. Idea about pseudo first order reaction.
3. Arrhenius equation (temperature dependence on rate constant), using this equation calculation of activation energy.
4. Determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.
5. Theories of reaction rates (Lindeman unimolecular theory, Collision theory, Transition state theory)
6. Mechanism and kinetics of homogeneous catalysis.

SEM-II

CC-3: Inorganic Chemistry-I

1. The Course helps in developing interest in understanding the structure of the atom and hence the properties of various forces occurring universe.
2. Chemical periodicity topic helps to develop the overall idea of the nature of the various elements, and their similarities.
3. Acid-Base Reactions Chapter provides the idea to differentiate the chemicals as acidic, basic, or neutral. Thereby, students can utilize the idea in day-to-day life while using fertilizer, soap, drinks, etc.
4. Oxidation-Reduction Reactions provide a clear concept of electron transfer among reagents. It directly helps to understand the working mechanism of batteries, electroplating, resistance against corrosion, etc.
5. Analysing the samples (based on redox principal students can easily estimate various ions quantitatively.

CC-4: Organic Chemistry – II

1. Detailed discussion on chirality, stereoisomerism is done along with the concept of pro-stereoisomerism. Conformation of organic molecules is discussed elaborately with their different terminology, energy profile diagram. The stability of different conformers is also discussed based on their terminology.
2. Kinetic studies and thermodynamic studies of organic reactions are done in the light of reaction mechanisms, solvent effects, substrate effects etc. with proper examples.
3. In laboratory session each student is required to carry out
    I. The synthesis of some special organic compounds using different types of reactions such as Diazotisation reaction, coupling reactions, Oxidation reactions, Hydrolysis reactions, greener approach to avoid hazardous chemicals etc,
    II. Purification of the compounds through recrystallization,
    III. Determination of the melting points of the synthesized product.

In such a way that the students will be capable enough to synthesis new organic compounds in future.

SEM-III

CC-5: Physical Chemistry-II (Transport Processes, Application of thermodynamics-I, Foundation of quantum mechanics)

1. Transport Processes:

1. Fick's law of diffusion and its application
2. Idea of liquid flow, viscosity of liquid, laws of viscosity
3. Understanding of determination of viscosity coefficient of liquid by falling sphere method
4. Effect of temperature on the viscosity of liquid and gas
5. Idea of conductance and application of conductance measurement.
6. Idea about transport number and using conductance calculation of transport number via different methods.
7. Qualitative idea about conductometric titrations and their applications.

2. Application of thermodynamics:

1. Learn the application of thermodynamics: partial molar quantities, Gibbs- Duhem questions, Fugacity, and fugacity coefficient.
2. Calculations of various thermodynamic functions for binary solutions.
3. Understand the equilibrium based on thermodynamic parameters.
4. Understand the Le Chatelier's principle from thermodynamics
5. Nernst distribution law and its application
6. Idea of condensed phase from thermodynamic point of view.

3. Foundation of quantum mechanics

1. Understand historical aspects of development of quantum mechanics
2. Understand and explain the differences between classical and quantum mechanics.

3. Develop an understanding of quantum mechanical operators, commutation, uncertainty principle, Hermitian operators, postulates of quantum mechanics.
4. Idea about particle in a box and simple harmonic oscillator system and their expression of wave function, energy.
5. apply principles of quantum mechanics to calculate observables on known wave functions.

CC-6: Inorganic Chemistry (II)

- In the Chemical Bonding Chapter, students gain knowledge about the type of interactive forces among the atoms and molecules. Thereby, they can predict the shape, structure, boiling, melting points, solubility, etc of various types of chemical components.
- Radioactivity chapter provides knowledge about the Law of radioactive decay, stability, and half-life of various isotopes. Students also know about the safety measures against radioactive emissions herein.
- In the practical curriculum, students gather a profound idea about how to estimate metal ions like copper and chromium in the alloys like brass and steel respectively.
- Students also get knowledge this semester on how to estimate Arsenic in various samples like groundwater.

CC-7: Organic Chemistry – III

1. Chemistry of alkene and alkyne compounds are discussed in detail with their classifications, preparations, physical properties and chemical properties with proper mechanisms along with suitable examples.
2. Mechanism of aromatic nucleophilic and electrophilic substitution reactions are discussed with proper examples.
3. Chemistry of carbonyl compounds and compounds containing active methylene groups, their preparations, chemical reactions are elaborately discussed which will helh the students to synthesis new organic molecules according to our requirement.

4. Last but not the least the concept of Umpolung is introduced using organometallic compounds in which the essence of the reaction is that it occurs through a reverse manner.
5. During laboratory session each student is required to carry out
    - Qualitative chemical tests for all the special elements and the functional groups with relevant derivative,
    - Determination of melting point of the solid organic compounds and their derivatives are also done which will help the students to identify unknown organic compounds.

SEC-1: Basic Analytical Chemistry

1. Analytical chemistry and its interdisciplinary nature are introduced. Role of significant figures, concept of sampling, data analysis in a proper way – are the different fields which discussed in detail so that the students will be capable to analysis the raw data after quantitative experiments.
2. Water analysis, soil analysis and analysis of food products and cosmetics are discussed theoretically which give the students a brief idea to these fields.
3. Chromatography technique and its different classifications are discussed theoretically in brief for the separation of different natural products.

SEM-IV

CC-8: Physical Chemistry-III(Application of thermodynamics-II, Electrical properties of Molecule, Quantum chemistry)

Application of thermodynamics-II

- Concepts of four colligative properties, their calculation, interrelations and applications.
- Concepts of phases, components, degrees of freedom, Gibb's phase rule and its applications, construction of phase diagram of different systems (one component

system, binary solutions i.e, two component system and three component system) , the application of phase diagram.

- Understand phase equilibrium, criteria, CST, Duhem-Margules equation.
- Idea about azeotropic solutions, eutectic mixture.

Electrical properties of Molecule:

- Basic principle of laws of electrochemistry.
- Concept of ion atmosphere
- Understanding about electrodes, EMF measurement, Nernst equation, chemical cells and their function.
- Learn the working of electrochemical cells, galvanic cell and concentration cells
- Qualitative idea about potentiometric titrations and their applications.
- Calculation of pH using glass and other electrodes.

Quantum chemistry:

- Concepts of angular momentum and spin, as well as the rules for quantization and addition of these.
  Idea about the rigid rotor model for diatomic molecules (Schrödinger equation) and calculation of wave function and energy for this model.
- How to convert Cartesian coordinates into spherical polar coordinates in quantum mechanics
- Application of Schrodinger equation in 3-D models, Schrodinger equation in spherical co-ordinates.
- How to solve the hydrogen atom problem by using quantum mechanics.
- Significance of LCAO and HF-SCF method.

CC-9: Inorganic Chemistry (III)

- In the chapter Metallurgy chapter, the pupil gets profound knowledge about metals. They learn deeply about the electrochemical series and thereby know the oxidizing and reducing nature of the metals. They also know how to extract and purify the metals from their Ore economically. The composition and utility of various alloys are also known from this topic.

- In the main group elements chapter (s and p block elements) we discuss the similarity and anomalous behaviors of elements. Here we also discuss the relative stability of different oxidation states, allotropy, and catenation, oxoacids and oxides of Nitrogen, Phosphorous, Sulphur, etc, various inorganic compounds, an inorganic polymer, their preparation, and their uses.
- In complexometric titrations the students learn how to estimate the hardness of water, thereby estimating the amount of Zinc, Magnesium, and Calcium in the given sample.
- They also learn how to prepare inorganic complexes which some show fluorescence.

CC-10: Organic Chemistry – IV

- Discussions are made on organic compounds containing as special element like nitro compounds, amines, alkyl nitrile, isonitrile, diazonium salts and their related compounds in detail along with their structure, synthesis, physical and chemical properties and their synthetic approach towards the formation of new organic compounds.
- Organic rearrangement reactions are discussed in detail and their usefulness to synthesis different new organic compounds are pointed out.
- Concept of Retrosynthesis is introduced to synthesis new organic molecules. 4. Detailed discussion on UV-Spectroscopy, IR-Spectroscopy and NMR are done.
- Discussions are made to identify the simple organic molecules using their UV-Spectroscopy, IR-Spectroscopy and NMR values.
- During laboratory session each student is required to carry out different quantitative experiments like estimation of Glucose, Vitamin-C, Formaldehyde, Acetic acid in Commercial Vinegar, Urea, Aromatic amines, Phenol etc.in their suitable sources. Estimation of saponification value of Ester is also carried out.

SEC-2: Pharmaceutical Chemistry

- Brief description of drug discovery, design and development of drugs are made in introductory session.
- Functioning of different drugs of different groups are discussed elaborately.
- Synthesis of drugs using retrosynthetic approaches is made.

- Preparation of different types of antibiotics, Vitamins, Amino acids and alcohols is discussed through different fermentation processes.
- The above discussion grows the curiosity of the students to the Drugs & Pharmaceutical sectors which enhances their practical skills.

SEM-V

CC- 11: Inorganic Chemistry (IV)

- In this semester we discuss coordination chemistry in detail. Students learn about the colour, magnetic behaviour, thermodynamic stability, chemical reactivity, kinetically lability, and inertness of coordinate compounds.
- Students also learn about the Lanthanide and Actinide elements, their extraction, separation, purification, and their critical use in technology.
- In this context pupils learn how to separate metal ions from their mixture using the paper chromatography technique. They perform gravimetric analysis for the estimation of nickel (II), copper, Al (III). They will also use spectrophotometric method to measure 10Dq of 3d metal complexes.

CC-12: Organic Chemistry –V

1. The students are taught here hardcore theoretical organic chemistry specially the polynuclear hydrocarbons and the heterocyclic compounds along with their synthesis and reactions with the reaction mechanisms.
2. Cyclic stereochemistry is introduced with conformational analysis with their symmetry properties and optical activity. The topic is made very interesting to introduce reactivity in cyclohexane system citing different examples from different types of reactions like Elimination, Substitution, Rearrangement, Merged substitution-elimination, epoxidation, saponification etc.
3. Different types of Pericyclic reactions like Electrocyclic, Cycloaddition, Sigmatropic reactions are discussed in detail with proper examples using Molecular Orbital approaches.
4. The chemistry of different natural polymers like Carbohydrates, Alkaloids, Terpenoids, biomolecules like Amino acids, Peptides, Nucleic acids etc. are discussed thoroughly with their structure elucidation, optical activity, their extraction, synthesis, both physical and chemical properties. Students will be well acquainted here with the environmental bio polymers.

5. During laboratory session each student is required to carry out
    - the separation of mixtures to their constituents using different types of Chromatographic techniques like TLC, PC, Column chromatography etc,
    - the assignment of labeled peaks in the IR Spectrum explaining the relative frequencies of the absorptions,
    - the assignment of labeled peaks in the 1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.

    Here the students will be well acquainted to identify an unknown organic compound by analyzing the spectral pattern of their IR and/or NMR Spectra.

DSE-1: Advanced Physical Chemistry (Crystal structure, Statistical Thermodynamics, Special selected topics)

1. Crystal structure:

- Concepts of Bravais lattice and laws of crystallography.
- Solids, lattice parameters – its calculation, application of symmetry, Crystal structure of simple salt.
- Qualitative idea about Miller and Weiss indices and their interrelations
- Determination of crystal structure via different methods (powdermethod)

2. Statistical Thermodynamics:

- Concepts of thermodynamic probability and relation with entropy.
- Concepts of ensembles.
- Calculation of entropy using 3rd law of thermodynamics.
- Concepts of partition functions.
- Idea about Maxwell's speed distribution and Gibb's paradox.

3. Special selected topics:

- Concepts of heat capacity of solids and related laws
- Knowledge of Polymer chemistry
- Calculation of dipole moment and polarizability.

4. Application of computer language to solve various chemical equations

DSE-2: Instrumental methods of chemical analysis

Our aim of this course is to focuses on the principles, techniques, and applications of modern analytical instruments used in chemical analysis. By the end of the course, students should be able to achieve several key outcomes:

1. Understanding Instrumental Techniques: Students will understand the fundamental principles, components, and operating mechanisms of various instrumental techniques such as spectroscopy, chromatography, electrochemical analysis, and mass spectrometry.
2. Analytical Applications: Students will learn the specific applications of each instrumental method in qualitative and quantitative analysis, including the types of samples and analytes best suited for each technique.
3. Data Interpretation: Students will develop skills in interpreting the data generated by different instrumental methods, including spectra, chromatograms, and electrochemical signals.
4. Problem-Solving: Students will enhance their ability to troubleshoot and solve problems related to instrumental analysis, such as resolving interferences and optimizing instrument performance.
5. Quantitative Analysis: Students will learn to perform quantitative analysis using instrumental methods, including calibration techniques, standard addition, and internal standards.
6. Ethical Research Practices: Students will understand the ethical considerations in instrumental analysis, including data integrity, environmental impact, and responsible use of chemicals and instruments.
7. Professional Standards: Students will adhere to professional standards and best practices in the conduct of instrumental analysis research and laboratory work.

OR DSE-2: Analytical methods in chemistry

Our aim of this course is to focuses on qualitative and quantitative aspects of analysis, optical methods of analysis, thermal methods of analysis and separation techniques. By the end of the course, students should be able to achieve several key outcomes:

1. Qualitative and quantitative aspects of analysis: Students will understand qualitative and quantitative aspects of analysis through sampling, evaluation of analytical data, estimating errors, accuracy and precision, normal law of distribution, indeterminate errors, statistical test of data etc.
2. Optical methods of analysis: Students will learn the Origin of spectra, fundamental laws of spectroscopy and selection rules, basic principles of different spectroscopic methods such as UV-Visible Spectrophotometry, Infrared Spectroscopy, Flame Atomic Absorption and Emission Spectroscopy and the fundamental principles, components, and operating

mechanisms of various spectroscopic instruments (choice of source, monochromator, and detector).

3. Thermal methods of analysis: Students will understand the theory of thermogravimetry (TG), basic principle of instrumentation and techniques for quantitative estimation of Ca and Mg from their mixture.

4. Electroanalytical methods: Students will learn the basic principles of quantitative analysis using different electroanalytical methods such as pH metric, potentiometric and conductometric titrations.
5. Separation technique: Students will able to develop their skills in different separation and extraction techniques that include qualitative and quantitative aspects of solvent extraction, chromatographic separation etc. They will perform separation and identification of the monosaccharides in a mixture by paper chromatography, separation of the active ingredients of plants, flowers and juices by TLC, extraction of metal complex and determination its concentration by spectrophotometry.
6. Students will develop skills to determine the pH of soil, chemical oxygen demand (COD) biological oxygen demand (BOD) using spectrophotometry.

SEM-VI

CC-13 Inorganic Chemistry- (V)

- In this context students knew about the role of ions (especially Na, k, Mg, Ca, Fe, Cu, and Zn) in biological systems. They also knew about Haemoglobin, Myoglobin, Hemocyanin, and Hemerythrin, we also discuss her biological Nitrogen fixation, and photosynthesis. Toxic metal ions and their effects, chelation therapy, etc.
- In organometallic chemistry, students gather knowledge about the types of bonds between carbon and various metals. There we discuss some important organometallic compounds like Zeise's salt, Ferrocene, etc. We also discuss their preparation and reactions.
- In practical classes students learn the qualitative semi-micro analysis of a mixture of radicals where the emphasis is given to the understanding of the chemistry of different reactions and assigning the most probable composition.

CC-14: Physical Chemistry-IV (Molecular Spectroscopy, photochemistry, surface phenomenon)

Molecular Spectroscopy:

i) Learn about interaction of electromagnetic radiation with molecules.

ii) Interpret rotational and vibrational, Raman and nmr spectra and know about their application.

Photochemistry

i) Knowledge of the laws of absorption of light energy by molecules and the subsequent photochemical reactions.
ii) Kinetics of photochemical reaction and quantum yield calculation.

Surface phenomenon

i) Adsorption – theory and significance.
ii) Langmuir, Freundlich – adsorption isotherms, significance.
iii) Understand the colloids and different types of electro kinetic phenomena, concept of micelles.
iv) Concepts of electrical properties of molecules and different types of intermolecular forces.

DSC-3: Polymer Chemistry

Polymer Chemistry focuses on the study of polymers, their synthesis, properties, characterization, and applications. By the end of the course, students should be able to achieve several key outcomes:

- Fundamental Concepts: Students will understand the fundamental concepts of polymer chemistry, including polymerization mechanisms, molecular weight distributions, and polymer structure.
- Types of Polymers: Students will learn about different types of polymers, such as thermoplastics, thermosets, elastomers, and biopolymers, and their specific properties and applications.
- Polymer Synthesis: Students will develop skills in synthesizing polymers using various methods, including addition (chain-growth) polymerization, condensation (step-growth) polymerization, and copolymerization.
- Characterization Techniques: Students will learn to use various techniques to characterize polymers, such as spectroscopy (NMR, IR), chromatography (GPC), and thermal analysis (DSC, TGA).
- Structure-Property Relationships: Students will understand the relationship between the structure of polymers and their physical, chemical, and mechanical properties.
- Material Design: Students will be able to design and synthesize polymers with specific properties tailored for particular applications.

- Problem-Solving: Students will enhance their ability to address real-world problems related to polymer applications, such as developing new materials with desired properties or improving existing materials.
- Industrial Applications: Students will learn about the applications of polymers in various industries, including packaging, automotive, aerospace, electronics, and medicine.

DSE-4: Dissertation followed by power point presentation

This course is designed to provide students with an opportunity to conduct original research, synthesize their findings, and effectively communicate their work. By the end of the course, students should be able to achieve several key outcomes:

- Research Mastery: Students will demonstrate a deep understanding of their chosen research topic, including key concepts, theories, and current research trends.
- Literature Review: Students will be able to conduct a comprehensive literature review, identifying relevant sources, gaps in the literature, and the context for their research.
- Research Design: Students will design a research project, including formulating research questions or hypotheses, selecting appropriate methodologies, and planning the research process.
- Data Collection: Students will gather and manage data using suitable techniques, ensuring data integrity and accuracy.
- Data Analysis: Students will analyze data using appropriate qualitative or quantitative methods, drawing meaningful conclusions from their findings.
- Problem-Solving: Students will develop problem-solving skills by addressing challenges and obstacles encountered during their research.
- Critical Evaluation: Students will critically evaluate their own research and the work of others, identifying strengths, weaknesses, and areas for improvement.
- Synthesizing Information: Students will synthesize information from multiple sources, integrating their findings into the broader context of their field.
- Continued Engagement: Students will be motivated to continue learning about their research topic and related fields, staying informed about new developments and emerging trends.
- Adaptability: Students will develop the ability to adapt to new challenges and incorporate emerging knowledge and technologies into their research practices.

Name of the Department: Chemistry

Programme Outcome

A student completing B.Sc. (Hons.) in Chemistry will acquire the following skills and knowledge which will enable him/her to pursue higher education.

1. The course helps in developing interest in understanding the relation between the universe and our mother planet. The primitive chemical reaction gives the answer from where the first biological cell appeared.
2. The students of Chemistry Hons. are required to perform simple experiments in the laboratory according to their syllabus to verify various concepts of basic chemistry which also help them to be a good chemist in the future.
3. Students pursuing Hons. in Chemistry generally require good level of understanding in Mathematics, Physics and Biological Sciences as well. Those help them to develop their analysing power towards different theoretical and practical phenomena which occurs in our surroundings.
4. The students gain profound knowledge of using different instruments like UV-Visible Spectrophotometer, IR Instruments, Polarimeter, pH-meter, Colourimeter, Conductivitymeter, Potentiometer, TLC, Paper Chromatography etc .and analysing the data obtained from them to identify different compounds, prepare new compounds etc.
5. Profound knowledge of computer operations and programming skills are also gained which helps them to operate different instruments and make new programs in the field of Quantum Chemistry and IT sectors.
6. The course creates interest in Higher Studies and Research in various branches of Chemistry e.g., Synthetic Organic Chemistry, Green Chemistry, Drugs and Pharmaceuticals, Natural Products, Polymer and Rubber, Paints and Varnishes, Glass and Ceramics, Nano-Chemistry, Bio-catalysts, Environmental Chemistry, Water analysis, Soil analysis, Quantum Chemistry, Computational Chemistry, Material Chemistry etc.
7. Chemistry has wide range of utility in our daily life. We start our day with tooth-paste and ends our night with our essential medicines through different food items and many chemical commodities like cosmetics, laundry item, different food additives, preservatives, plastics, rubbers, different fertilizers, pesticides, herbicides etc.
8. So, the students pursuing Chemistry Hons. have Career opportunities in various field like Health-Care Sector, Daily-Care Sector, Polymer & Rubber Industry, Building & Construction Sector, Fertilizers and Food Processing Sector, Pathological Sectors etc.

9. Moreover, students have also bright career opportunities in various academic institutions & Research institutions.