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REVIEW ARTICLE
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REVOLUTIONIZING THERAPY: EXPLORING THE PROMISING ROLE OF P-BLOCK ELEMENTS IN MEDICINE

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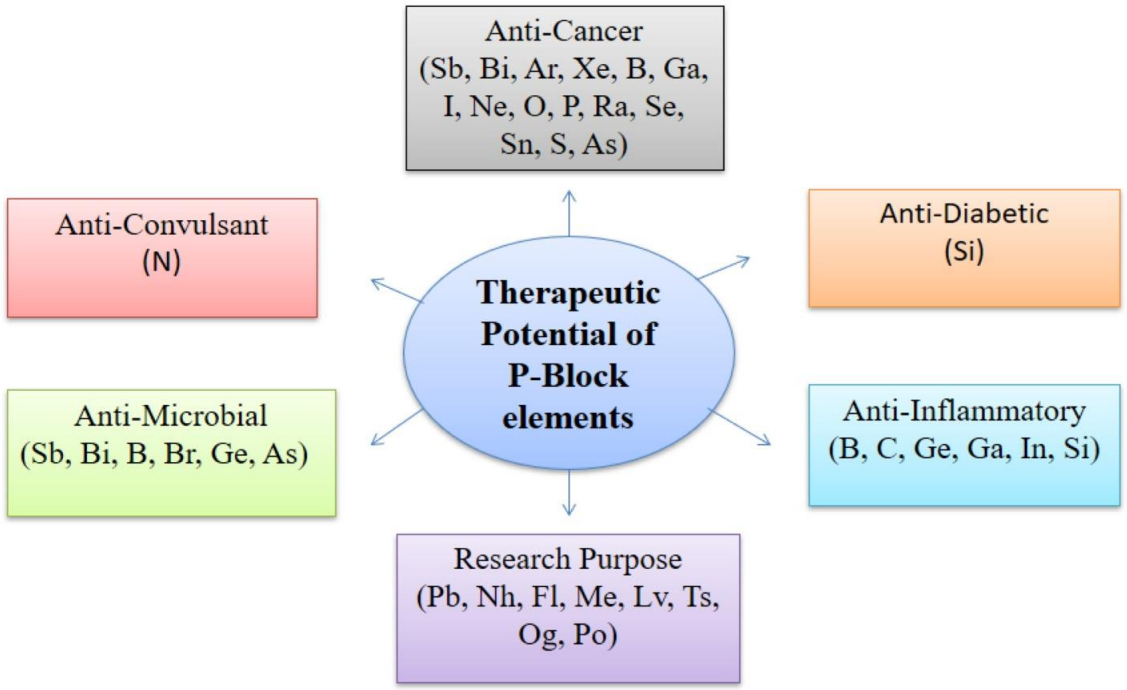
Abstract
P-block elements have a long and varied history from ancient times. In pharmacological therapy, P-block elements might have some advantages over purely organic compounds. Such as dental problems, drug delivery, eye, respiratory, and gastrointestinal diseases. These elements are also used as anti-cancerous drugs, anti-ulcerative drugs, anti-microbial, anti-bacterial, anti-fungal agents, etc. For example, antimony (anti-protozoal), bismuth (anti-ulcer), gold (anti-arthritic), iron (anti-malarial), platinum (anti-cancer), and silver (antimicrobial) compounds in the treatment of various diseases. This review is the collection of pharmacological and therapeutic advantages of P-block elements. Many different transition metal and main group element compounds have been studied for their potential anti-tumor action. Although P-block elements are widely used to treat a wide range of illnesses, few of them have been scientifically screened out. Even though research into the potency of p-block elements has advanced tremendously, efforts to find newer therapeutic candidates continue. Therefore, research into the untapped potential of P-block elements should be done.

Key Words: P-block Elements**,** Pharmacological Potential, Anti-cancer activity, Anti-microbial potential, Anti-inflammatory effect.

Graphical Abstract



Introduction

The use of P-block elements (metal-based drugs or noble gases) can be traced back to ancient times and has a rich and varied history (1). Gold-based medicines were being used in China and the Middle East as far back as 3500 years ago and mercurous chloride (Hg_2Cl_2) was used as a diuretic during the Renaissance period, for example (2, 3). More recently in the early twentieth century Paul Ehrlich, who coined the term “chemotherapy”, developed Salvarsan, an arsenic, as a drug for the treatment of syphilis (4). Current medicinal inorganic chemistry though is a comparatively young but vibrant research discipline. There are many examples of metal-based therapeutics and diagnostics.

P-block elements may offer certain advantages over purely organic compounds in drug therapy (5). For example, the coordination of an organic molecule to a metal center may modify the normal metabolic path and may lead to a slow-release mechanism for delivery of the organic molecule, i.e., the metal complex may function as a prodrug (6). Nevertheless, the importance of such compounds in medicine is undisputed as can be judged by the use of, for example, antimony (anti-protozoal), bismuth (anti-ulcer), gold (anti-arthritic), iron (anti-malarial), platinum (anti-cancer) and silver (antimicrobial) compounds in the treatment of various diseases (7). In terms of anti-tumor activity, a wide range of both transition metal and main group element compounds have been investigated for efficacy (8, 9).

The development of bulk production of radioactive isotopes has quickened tracer research in biology and opened a new field of medical applications (10). There is already a large literature dealing with the medical uses of radioactive phosphorus, iron, sodium, carbon and iodine (11). The two main trends of research today are first, utilization of the labelling property of isotope radioactivity, since they are not distinguished physiologically by the body from the stable forms and yet are quantitatively detectable by their emitted ionizing radiations; secondly, their utilization for selective and local tissue irradiation (12). Radioactive isotopes can be used in the laboratory and in the body in the synthesis of compounds which then become labelled (13). Thus, the ingestion of radio-active iron leads to the formation of labelled hemoglobin and the production of' tagged' red cells (14).

According to a growing amount of studies, some noble gases might exert cytoprotective effects that could be bound to several clinical applications, including the prevention/ inhibition of

ischemia/reperfusion-induced tissue damage (15, 16, 17). Noble gases include helium, argon, krypton, neon, xenon, and radon) (18)

Table 1.1. P-block Elements (Symbols and names)

B Boron	**C** Carbon	**N** Nitrogen	**O** Oxygen	**F** Fluorine	**Ne** Neon
Al Aluminum	**Si** Silicon	**P** Phosphorous	**S** Sulfur	**Cl** Chlorine	**Ar** Argon
Ga Gallium	**Ge** Germanium	**As** Arsenic	**Se** Selenium	**Br** Bromine	**Kr** Krypton
In Indium	**Sn** Tin	**Sb** Antimony	**Te** Tellurium	**I** Iodine	**Xe** Xenon
Tl Thallium	**Pb** Lead	**Bi** Bismuth	**Po** Polonium	**At** Astatine	**Rn** Radon
Nh Nihonium	**Fl** Flerovium	**Mc** Moscovium	**Lv** Livermorium	**Ts** Tennessine	**Og** Oganessine

Pharmacological Potential of Various P-Block Elements

Aluminum

Dental Problems

Alum water solution is used as a gargle to treat mouth ulcers, bleeding gums, inflammatory conditions of gums and teeth, and also in excessive salivation (19, 20) Along with roghane gul and vinegar it is used to treat gum ulcers (21). Gargling with a decoction of black pepper and alum or by locally applying these two in powdered form removes toothache, strengthens the gums, and fixes loose teeth (22).

Eye Diseases

It can be used in conjunctivitis and keratitis (20). Eyewash with its solution is used in the burning eye and pus discharge from the eye. Thickening of the eyelid and blepharitis are cured by the use of alum with honey (21). An Equal quantity of alum, opium, and rasaut (barberry extract) pounded in water is applied around the ear to relieve eye pain in children (19). Appling a few drops of 250mg alum pounded in 30ml rose water (distilled) reduces red eye and excess waste production (23).

Respiratory Diseases

Keeping over the tongue powdered alum in the dose of 10 grains prevent an asthma attack. Keeping it below the pillow of a while sleeping prevent snore (24). Paste made by mixing powdered alum and murmaki (myrrh) in equal quantity in honey is applied into the ear with cotton to relief otalgia. It is also used in pertussis and diphtheria especially in children (19).

Gastrointestinal Diseases

Oral use of alum removes nausea and vomiting, act as stomach and liver tonic. It can be used in chronic diarrhea due to its astringent property (16). In case of chronic diarrhea oral use of alum with opium is helpful (25). Because of its local hemostatic property, it can be given in gastrointestinal bleeding. Douching with alum solution in rectum act as wormicide. (26)

Drug Delivery

Most of the drugs are delivered into the body principally using the oral or intravenous route (27). However other strategies need to be adopted to deliver drugs containing biological agents such as proteins (28) and this is when nanoparticles come into play. Alumina nanoparticles are also considered for drug delivery applications due to their potential scavenging behavior (29). The scavenging property has been related to their ability to act as direct antioxidants, block Reactive oxygen species (ROS) production and also cause a reduction in ROS production (30).

Orthopedics

Because ceramic nanocomposites can mimic the chemical, biological, and mechanical properties of bone, they are being evaluated as possible third-generation orthopedic biomaterials (31). High fracture resistance, flexibility, and a weight-to-strength ratio are desirable qualities for materials used in orthopedics (32). Metal oxide nanoparticles will likely play a significant role in the medical area in the future, as the application of aluminum oxide nanoparticles is still developing (33).

Antimony

Anti-Leishmaniasis

The majority of antimony-containing medications are used to treat leishmaniasis (34). Sandflies inject parasites into mammals to induce leishmaniasis, resulting in both cutaneous and visceral illnesses (35). In practical practice, antimony(V) compounds such as sodium stibogluconate (Pentostam®) and meglumine antimonate (Glucantime®) are used to treat Leishmaniasis, despite the theory that antimony(V) is transformed to antimony (III) species in vivo (35).

Potential Anti-Tumor Activity of Antimony (III) Compounds

Although this compound's 1:1 adduct with $SbCl_3$, or $SbCl_3L$, exhibited no activity against Ehrlich ascites tumor and L1210 leukemia, it is reported to have significant anti-tumor activity in a few malignant neoplasms (36). Other metal coordination compounds containing cyclophosphamide were likewise ineffective. The anti-tumor potential of a number of antimony (III) compounds containing polydentate carboxylic acids has also been studied (37).

Potential Anti-Tumor Activity of Antimony (V) Compounds

Two researches have been published on the cytotoxicity of antimony (V) compounds. Several triphenyl antimony (V) polyamines and their potential inhibitory effects were covered in the initial release (38). All the chemicals showed some inhibition, and the results showed that more inhibition was often associated with higher dosages. Adenine-derived dianions (H_2NR_2) and 2,6-diaminoanthraquinone (H_2NR_7) were shown to be the most effective chemicals in the series of three cell lines (BHK-21 baby hamster kidney, L929 mouse connective tissue, and HeLa human epithelioid carcinoma) (39). When compared to other cell lines, the molecule containing the dianion produced from 2,4-diamino-5(3,4 dimethoxybenzyl) pyrimidine (H_2NR_6) showed selectivity against the BHK-21 cell line (37).

Bismuth

Anti-Ulcer Drug

Recently, the use of bismuth in medicine has been investigated (40, 41). In the past, bismuth compounds were used to treat a wide range of ailments; today, they are primarily used as anti-ulcer drugs in clinical settings (42). It can be treated with colloidal bismuth subcitrate (De-Nol®), which is also used in conjunction with bismuth subsalicylate (Pepto-Bismol®) to treat and prevent duodenal and stomach ulcers (43). A recently discovered drug called ranitidine bismuth citrate (Pylorid® and Tritec®) is another option for treatment. It is currently uncertain what the actual medicine formulations' precise contents are (44).

Potential Anti-Tumor Activity of Bismuth (III) Compounds

The compounds containing the anion generated from 6-mercaptopurine were among the first to be tested for their anti-tumor properties. The thiol's established anti-leukemic properties served as inspiration for these (45, 46). Results for $Bi(SR1)_3$ in humans inoculated with L1210 leukemia is used for its recovery. Several other investigations of bismuth thiolates were undertaken (37).

Peptic Ulcer

The standard triple therapy drug treatment, which includes a proton pump inhibitor (PPI) and two antibiotics (such as metronidazole, tetracycline, amoxicillin, or clarithromycin), is the first line of

treatment for *H. pylori* (47). The first line of treatment for *H. pylori* is usually triple therapy medicine, which consists of two antibiotics (such as metronidazole, tetracycline, amoxicillin, or clarithromycin) and a proton pump inhibitor (PPI) (48, 49). Consequently, triple treatments with bismuth are increasingly recommended as the initial course of treatment in several countries (50). The more recently developed bismuth subsalicylate (Pepto Bismol, BSS), colloidal bismuth sub citrate (De-Nol, CBS), and ranitidine bismuth citrate (Pylorid, RBS) are among the therapeutically utilized medications, as previously mentioned (51).

Antimicrobial

In addition to *H. pylori*, bi compounds have been used with efficacy to treat other bacterial illnesses (52). Related infections include syphilis (e.g., potassium bismuth tartrate, bismuth quinine iodide, and iodobismitol), colitis (bismuth subnitrate, bismuth citrate), diarrhea (BSS and bismuth nitrate), and wound infections (bismuth oxide) (53). BSS, for instance, is widely recognized for its curative and preventive qualities with regard to diarrheal illnesses (54). It's in vitro antibacterial effectiveness against enterotoxigenic *E. coli*, the primary bacterial cause of diarrhea in developing countries and the dreaded "travelers' diarrhea," has been shown. It has been suggested that BSS can considerably lower *E. coli*'s toxin secretory activity (55). Furthermore, both BSS and CBS are active against *C. difficile*, another entomopathogen. BSS demonstrated significant efficacy in an in vivo hamster model of *C. difficile* colitis (56), whereas CBS had an in vitro minimum inhibitory concentration of 90% of growth (MIC90) of 128 μg/L (57).

Argon and Xenon

For Treatment of Hemorrhagic Radiation Proctitis

For the treatment of hemorrhagic radiation proctitis, argon laser therapy works well. It is better than surgery, which could necessitate the development of a colostomy (58). Moreover, 12% to 80% of patients experience operational morbidity, and up to 47% of patients die. Theoretically, Argon laser therapy offers advantages over Nd: YAG laser therapy. Hemoglobin is the only tissue that preferentially absorb argon laser energy, which only pierces 1 mm (59). Tissue proteins absorb Nd: YAG laser energy in a non-specific manner once it penetrates 3 to 5 mm. Transmural necrosis and fibrosis with perforation or stricture formation could result from this (60, 61, 62). Argon and Nd: YAG lasers work just as well together to treat different types of vascular lesions. But in 5% to 15% of patients, Nd: YAG therapy in the small intestine, colon, and rectum is linked to major problems (63). It was reported that a rectovaginal fistula developed in one CRP patient receiving Nd:YAG treatment (64). With the argon laser, no such issues have arisen (65).

Treatment of Keloids

There has been discussion about the potential advantages of laser therapy for keloids. Reports have surfaced from time to time extolling the benefits of $C0_2$ or argon lasers in this regard (66, 67). The trunk's midsternal and deltoid muscles were the primary body parts treated.

Automated Fluorescence Microscopy Reveals the Cytoprotective Activity of Argon and Xenon

An experimental system that enables the automated fluorescence microscopy-based assessment of cell number upon the culture of human osteosarcoma U2OS cells stable expression of a histone 2B-red fluorescent protein chimaera in the presence of pre-determined gas mixtures is used to assess the potential cytoprotective effects of inert gases (68). As a result, U2OS cells were grown in either a control atmosphere (75% N_2, 20% O_2, and 5% CO_2) or an atmosphere where N_2 was replaced with any one of six alternative gases (He, Ne, Ar, Kr, Xe, or N_2O), with the concentrations of O_2 and CO_2 remaining unchanged. Following the experiment, culture plates were automated for automated quantification of the number of residual cells using an imaging platform based on fluorescence microscopy (69). This experimental strategy showed that Ar and Xe can stop the apparent cell loss caused by multiple different cytotoxic agents (which could indicate either lethal effects, antiproliferative effects, or a combination of both) but He, Ne, Kr, and N_2O cannot (70).

Ischemic Neuroprotective Models

Out of all the possible applications for argon in medicine, research on its capacity as a neuroprotective agent has received the greatest attention (71). Research on neuroprotection aims to enhance patients' ability to regain their motor and behavioral abilities after suffering from neurological damage, including but not limited to physical trauma (72). The majority of argon neuroprotective research has focused on ischemic brain injury models, in which the brain is deprived of vital nutrients like oxygen and glucose (73), which can cause tissue damage and trigger apoptotic and inflammatory pathways in the surrounding tissues that ultimately result in the death of neurons (74). The common methods of which argon neuroprotection treatments have been examined are Oxygen-Glucose Deprived (OGD) environments, Traumatic Brain Injury (TBI), and the Middle Cerebral Artery Occlusion (MCAO) models (75). These methods are highly accepted for establishing ischemic brain injury treatments in rodent models (76).

Astatine

Anti-Cancer

Sodium astatine ([211At]NaAt) and labeled amino acid analogs ([211At]PA and [211At]AAMT) are useful for the treatment of thyroid cancer, malignant glioma, pancreatic cancer, and malignant melanoma (77). An investigator-initiated clinical trial using [211At]NaAt in patients with refractory thyroid cancer (ClinicalTrials.gov Identifier: NCT05275946) is in progress (77). We also developed a novel labeling method using the substitution reaction of 211At with dihydroxyboryl groups (78). 211At-labeled PSMA compound ([211At]PSMA5) and its therapeutic effect in a mouse xenograft model of prostate cancer and compared it with two closely related new derivatives, namely [211At]PSMA1 and [211At]PSMA6 (79).

Boron

Antibacterial Agent

Two essential substances for medicine are boric acid and sodium borate (80). Liquid dosage forms of boric acid are used as topical anti-infectives due to its weak bacteriostatic properties (77). Its solutions are appropriate for application on the cornea of the eye, and it doesn't cause irritation. Boric acid aqueous solutions are used as mouthwash, eyewash, and bladder irrigation (78). Denture adhesives use it as an alkalizing agent. Sodium perborate is a local anti-infective and oxidizing agent (81). Pharmaceutical formulations that are alkaline are kept at a constant pH using a variety of borate buffers (82).

Antifungal Agent

As a fungistatic agent, boric acid has been used to treat persistent vulvovaginal candidiasis (83). It works well against infections brought on by non-*Candida albicans*, *Trichomonas vaginalis*, *Aspergillus niger*, and different species of Candida *(Candida albicans, Candida glabrata, Candida krusei, and Candida parapsilosis*) (84). Psoriasis, trophic ulcers, trabecular bone quality, dermatophytosis, acute eczema and neural morphallaxis have all been treated with boric acid (85). Boric acid is used as a fungistatic agent in topical creams, intravaginal capsules (600 mg), vaginal suppositories (600 mg), and a 2.5% aqueous-alcoholic solution (30:70, v/v) (86).

Chemo Preventive Agent for Human Cancer

Studies on the toxicity and carcinogenicity of boric acid in both male and female mice have shown that this substance is not carcinogenic (86). In order to treat glioblastoma, melanoma, and other diseases, boron neutron capture therapy uses boron carriers such as boric acid and boronated compounds (87). The efficacy of these compounds in cancer treatment has been assessed through pharmacokinetic analyses that describe their biodistribution, tumour uptake, and tumour selectivity, as well as the impact of electroporation on apoptosis (88).

Wound Treatment

It has been discovered that boric acid is crucial for wound healing. Deep wounds with tissue loss have been treated with a 3% boric acid solution (89). Its effect on the extracellular matrix has been shown to significantly improve wound healing (90). In a study, boric acid's effects were mimicked by boric derivatives (triethanolamine borate, N-diethyl-phosphoramidate propylboronic acid, 2,2-dimethylhexyl-1,3-propanediol- aminopropylboronate, and 1,2 propane diolaminopropyl boronate) (86). Open wound healing is commonly managed with a combination of aqueous boric acid and calcium hypochlorite solutions (91).

Bromine

Otilonium Bromide Against Vibrio Vulnificus

According to recent research, otilonium bromide exhibits antimicrobial activity against *Clostridium difficile, Staphylococcus aureus*, and *Acinetobacter baumannii* (92). For *S. aureus*, otilonium bromide inhibited biofilm formation, but not for *V. vulnificus*. (93) This study examined the effects of otilonium bromide's antimicrobial mechanisms on *V. vulnificus* growth modulating factors, swarming motility, adhesion, and efflux pump. (94)

Carbon

Anti-Inflammatory Activity

Significant anti-inflammatory activity was produced by the chloroform extract ($p<0.05$) (95). Non-steroidal anti-inflammatory medications typically work by inhibiting prostaglandin synthetase in the hypothalamus to reduce inflammation (96). Therefore, the inhibition of prostaglandin synthesis in the hypothalamus may account for the chloroform extract of *P. fascicularis*'s anti-inflammatory properties (97).

Moreover, preliminary photochemical screening revealed the presence of proteins, flavonoids, terpenoids, alkaloids, and tannins in chloroform extract (98). One or more of the aforementioned phytoconstituent groups may be responsible for the anti-inflammatory action (99).

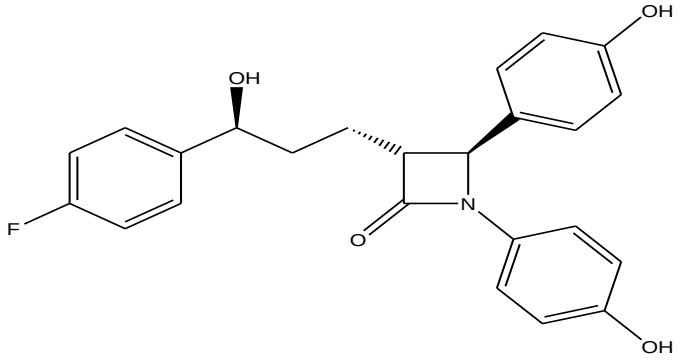
Antipyretic Activity

Significant antipyretic activity was produced by chloroform extract ($p<0.05$) (100). There was a discernible antipyretic effect from chloroform extract (p 0.05). Traditionally, prostaglandin synthetase in the hypothalamus is inhibited by non-steroidal anti-inflammatory drugs to produce their antipyretic effect (101). Thus, it is likely that the inhibition of prostaglandin synthesis in the hypothalamus contributes to the antipyretic action of *P. fascicularis* chloroform extract (102).

Fluorine

Ezetimibe (Zetia™)

A first-of-its-kind substance, ezetimibe (ZetiaTM) prevents the intestinal absorption of cholesterol and is a prime illustration of the function of fluorine substitution in metabolism-based medication optimization (103).



Ezetimibe

Chlorine

Chloride Channels as Drug Targets

Based on how they are regulated, mammalian chloride channels can be classified into five main classes: voltage-gated chloride channels (ClCs), calcium-activated chloride channels (CaCCs), ligand-gated chloride channels (GABA (γaminobutyric acid) and glycine-activated), and volume-regulated chloride channels (104). Cystic fibrosis transmembrane conductance regulator (CFTR) is activated by cyclic AMP-dependent phosphorylation. Clinical applications exist for ligand-gated chloride channel modulators, such as benzodiazepines and barbiturates for GABA A-gated chloride channels (105).

Gallium

Radiogallium Compounds as Tumor Imaging Agents

Early research showed that malignant cells were localized in tumor-bearing animals injected with radioactive gallium (67Ga citrate) (106). As a result of this finding, the 67Ga scan was created to help patients identify malignant tumors (107). For the most part, 67Ga scanning has been utilized in patients with Hodgkin's and non-Hodgkin's lymphomas over the past 20 years in order to identify disease that is still present or has returned after receiving chemotherapy or radiation therapy (108, 109). The amount of 67Ga incorporation in lymphoma cells is a good indicator of the tumor's metabolic activity and the existence of live malignant cells (110). Therefore, following lymphoma treatment, a positive 67Ga scan typically suggests the existence of residual cancer and the requirement for additional therapy (111).

Antineoplastic Activity of Gallium Nitrate in Cancer Treatment

The National Cancer Institute (NCI) conducted research on the anticancer properties of group IIIa metal salts, namely aluminium, gallium, indium, and thallium, in tumor-bearing CDF1 mice and Sprague-Dawley rats. This was motivated by the ability of 67Ga to localize in tumour cells (112). Gallium nitrate turned out to be the least hazardous of these metal compounds and the most successful at slowing the growth of tumours implanted subcutaneously. Consequently, it was promoted to NCI investigational drug status (NSC 15200) so that Phase 1 and Phase 2 clinical trials could evaluate its toxicity and antitumor efficacy (113). Gallium nitrate was given in those clinical studies according to two different schedules: a quick intravenous infusion lasting 15 to 30 minutes, or a continuous intravenous infusion that lasted 24 hours over a period of 5 to 7 days (114).

Potential Application of Gallium Compounds as Immunosuppressive and Anti-Inflammatory Agents

The research of Betoulle et al., which employed an aquatic system to demonstrate that fish (carp) exposed to sublethal concentrations of gallium nitrate in the water for up to 96 hours displayed a significant reduction in immune parameters including immunoglobulin production, phagocyte killing ability, and blood leukocytes, provided evidence that environmental gallium per se may be immunosuppressive (115). Gallium compounds have been shown in several studies to have immunosuppressive activity in animal models of autoimmune disease, both in vitro and in vivo. In rat models, gallium nitrate has been demonstrated to suppress experimental autoimmune encephalomyelitis and prevent adjuvant inflammatory arthritis by suppressing T-cells and macrophage function (116, 117). Research revealed that gallium nitrate can stop cardiac allograft rejection in mice and suppress lupus (118, 119).

Germanium

Anti-Cancer Agent

As an anticancer medication, spiro germanium is a novel azaspiran-germanium compound that was first described in 1974. It is presently undergoing clinical trials (120). It has been demonstrated that this substance is cytotoxic to tumour cell lines both in vivo and in vitro (121). It has also been

demonstrated that Spiro germanium (SG) exhibits cytotoxic activity against Plasmodium falciparum strains (122).

Anti-Malarial

Significant in vitro activity of Spiro germanium was shown against chloroquine-resistant (FCB, FTA, FVO) and sensitive (FSL, FUI, FH) strains of Plasmodium falciparum (123). After exposure to concentrations ranging from 2.48 to 9.9 rim/ml for 36 hours, the growth and maturation of the parasites was inhibited (124).

Indium

The Extent of Inflammation in Inflammatory Bowel Disease

A novel imaging technique called indium 111-leukocyte scanning has been presented for the evaluation of inflammatory bowel disease. (125) Its precision in determining the degree of inflammation is on par with radiology (126); in evaluating disease activity, a straightforward scan grading system demonstrated a robust association with the Crohn's disease activity index. (127) Measuring the excretion of labelled cells in the faeces following the scan allows for the evaluation of disease activity (128).

Indium-Ill Antimyosin Imaging

Myocyte necrosis can be identified by indium-111 antimyosin imaging in ischemic, inflammatory, and toxic heart diseases (129). This makes it possible to assess the location, severity, and amount of myocardial necrosis noninvasively (130). When myocardial infarction patients undergo simultaneous perfusion imaging, it is possible to distinguish between necrosed and perfused areas as well as different levels of mismatch and overlap, all of which have an impact on the prognosis (131). When evaluating patients with unstable angina or those whose diagnosis of unstable angina or infarction is unclear, antimyosin imaging can be helpful. (132)

Iodine

Radioactive Iodine-125 in Tumor Therapy

Brachytherapy (BT) is a primary method of administering radiation therapy that involves inserting radioactive sources into patients' bodies using interstitial or intraluminal applicators (133). BT can achieve outcomes that are not achievable with external beam radiation therapy (EBRT) or stereotactic body radiation therapy (SBRT), such as delivering extremely high prescribed doses inside the target lesion with minimal dose to the surrounding normal tissues (134). As a result, BT has been called the most conventional therapeutic approach. Recently, brain, oral/maxillofacial, pulmonary, hepatic, pancreatic, and, most frequently, prostate cancer have all responded very well to BT treatment. (135)

Krypton

Analgesic and Opioid-Like Effects

Kratom has long been used in Southeast Asia to treat pain and ease the symptoms of opium withdrawal (136, 137, 138, 139). People in the West are using kratom more frequently to manage their own pain or to help them stop using opioid medications like heroin and prescription painkillers (140, 141).

Neon

Helium-Neon Laser Irradiation

Since the temperature of the tissue exposed to laser radiation does not immediately rise, low-level laser therapy (LLLT) reactions are nonthermal (142). The helium-neon (He-Ne) laser, which emits red light with a wavelength of 632.8 nm, is a common example of a laser used in LLLT (143). Red light is a great source of stimulation for many growth factors and is useful for wound healing and superficial conditions, but it does not penetrate the skin very well below the surface (144). The highest relative percentage of incident energy is delivered to a specific volume of tissue by He-Ne laser light,

which can penetrate as deep as 0.5 mm into recently excised human skin (145). Since the majority of the target cells for LLLT's induction of wound healing—fibroblasts, keratinocytes, macrophages, and endothelial cells—are found in the epidermis and upper dermis, a penetration depth of even a few microns can be considered sufficient. (146)

Helium-Neon Irradiation Accelerates the Phagocytic Activity

In order to treat pulmonary tuberculosis, intravenous nitrogen laser exposure (He-Ne laser, 337.1 nm) is being used as an adjuvant (632.8 nm) and intra-cavitary adjuvant to chemotherapy, with encouraging results (147). Despite not having any direct antibacterial properties, the He-Ne laser can photo bioactivate human macrophages by raising their lysozyme and acid phosphatase activity, which in turn raises their phagocytic activity (148). The key to controlling tuberculosis appears to be the effective intracellular destruction of the phagocytosed M. tuberculosis bacteria (149).

Nitrogen

Anti-Convulsant

An important class of both natural and synthetic products, nitrogen heterocycles has a variety of beneficial pharmacological properties (150). Indole, oxadiazole, triazole, thiadiazol, triazines, pyrimidines, pyridines, and quinazolines are examples of heterocycles containing nitrogen. Over time, the pharmacology and development of these heterocyclic rings have consistently piqued interest (151). These heterocyclic rings also meet the Dimmock parameter postulate, which is a need for any compound to have anticonvulsant properties (152).

Oxygen

Reactive Oxygen as Anti-Cancer Agent

Natural products that are unavoidably produced during cellular metabolism are known as reactive oxygen species (ROS). Since they are extremely reactive, they can harm cells' lipids, proteins, and DNA (153). While long-term low ROS levels support vascular illnesses like arteriosclerosis, high ROS levels can cause apoptosis (154). Even though ROS appear to be disastrous for life, a growing body of research indicates that they actually play beneficial roles in treating human diseases as chemotherapeutic agents (155). In this way, numerous anti-cancer medications that produce ROS and induce oxidative stress-induced apoptosis in cancer cells have been developed. Because ROS can function as both chemotherapeutic agents and disease causation, their effects are paradoxical (156).

Phosphorous

Phosphorus Dendrimers as Anticancer Agents

Phosphorus-containing dendrimers, which come in a variety of forms, have intriguing characteristics and are widely used in pharmaceutical domains like medication delivery (including gene transfection), diagnostics, and imaging (157). It is possible for therapeutic agents to be physically adsorbed onto the dendrimer surface, chemically attached, or enclosed within the dendritic architecture (158). As an alternative, phosphorus dendrimers can be made into pharmaceuticals and used to treat conditions like cancer, infections, inflammations, and neurodegenerative illnesses (159).

Radon

Anti- Tumor Agent

In radon/radium spas like Misasa Onsen Izumi (Tottori) and Tamagawa Onsen (Akita) in Japan, radon has been used for many years to treat a variety of ailments, including low back pain, high blood pressure, and cancer (160). It has also been used as an adjuvant therapy for four additional types of cancer: liver cell, colon, uterine, and lung (161). Following high-dose radiation therapy or conventional chemotherapy, the four patients asked for radon. All four cases showed a respectable recovery, which is somewhat unexpected considering that harsh side effects of traditional anticancer medications suppress immunity (162). It appears that the very strong stimulation that the radon

treatments produced countered these effects and produced a potent action against the cancerous cells (163).

Selenium

Anti-Alzheimer Drug

While low and intermediate doses of selenium inhibit cancer cell proliferation and have a therapeutic effect on neurological diseases like Alzheimer's disease, high doses of the mineral promote the proliferation of cancer cells and have neurotoxic effects (164). Treatment with selenium may reduce the likelihood of memory impairments in AD patients. Research on the function of selenium and selenoproteins in neurodegenerative illnesses, such as AD, has gained significant attention (165). Selenoproteins are proteins that include the amino acid selenocysteine, which is a form of selenium (166). The primary site of selenium protein expression in the human brain is thought to be connected to antioxidant processes, which are essential in delaying the development and course of Alzheimer's disease (167).

Silicon

Vascular Disease and Atherosclerosis

Studies on biochemistry and epidemiology have identified silicon as a protective trace element in atherosclerosis (168). Moreover, it has been proposed that chronic illnesses like atherosclerosis are exacerbated by the observed decline in silicon concentrations with ageing (169). Human connective and elastic tissues, and the normal human aorta in particular, contain the highest concentrations of silica (170). In this tissue, silica appears to act as a crosslinking agent, stabilizing collagen and possibly fortifying the vasculature. The amount of silicon in arterial walls is greatly reduced by atherosclerosis. Furthermore, silicon levels drop just before plaque formation, which could mean that blood vessel walls are inherently weaker due to silicon deficiency (171).

Anti-Diabetic

In the following work, mice that were hyperleptinemia, hyperinsulinemia, and hyperlipidemia-prone were used to examine the antidiabetic effects of silicon (50 ppm silicon for 8 weeks) (172). It's interesting to note that silicon and coral sand, which is high in silicon, have antidiabetic effects. These effects include decreased blood glucose levels, increased insulin sensitivity, and improved reactions to the adipokines adiponectin and leptin (173).

Wound Healing

In medicine and surgery, silica is already widely used in tissue engineering applications that involve organ and wound regeneration (174). Collagen scaffolds, which are used as sponges, thin sheets, or gels, are the usual form for this. The ideal pore structure, permeability, hydrophilicity, and stability in vivo of collagen, a long fibrous structural protein, make it suitable for tissue regeneration (175). Collagen scaffolds therefore allow for the deposition and proliferation of cells such as osteoblasts and fibroblasts, thereby facilitating normal tissue growth and restoration (169). Research indicates that dietary silicon may also have positive effects on the healing of wounds (176).

Tin

Dentifrices and Mouthwashes

Since 1947, dental healthcare has employed tin (I1) fluoride (SnF) as a preventative measure against dental enamel dissolving in lactic acid (177) and tin is more efficient than sodium fluoride. Later research revealed that SnF inhibited the formation of dental plaque better than any other fluoride (178).

Use of Tin in Radiopharmaceuticals

In conjunction with metastable technetium-99 (99"'Tc) as a scanning agent in scintigraphy, tin salts such as SnC12.2H20, SnF, Sn2P207, Sn(OH),.xH,O have been used for routine diagnostics for the

past fifteen years (179). The optimal nuclear properties of 99mT make it easy to perform scintigraphy on the liver, pancreas, spleen, kidney, heart, gall bladder, lung, and skeleton (180).

Tin-Haem as a Therapeutic Agent for Treating Jaundice

Hyperbilirubinaemia is a condition primarily seen in newborns whose livers have not fully matured to the point where they can no longer detoxify the bile pigment bilirubin (181). Neonatal jaundice is the term for this condition, which can occasionally develop into a dangerous illness with neurotoxic symptoms. The breakdown of haem:(protoporphyrin IX) iron(I1) by haem oxygenase results in biliverdin, which is then reduced to bilirubin by biliverdin reductase (182). Tin-haem, also known as dichloro(protoporphyrin 1X)tin (IV), is a strong haemoxidase inhibitor (183).

Thallium

201 Thallium Chloride Scan for Thyroid Nodule

Thyroid imaging is one of the most useful adjunctive methods available for treating thyroid disorders; physical thyroid examination is the most important aspect of thyroid disease management. Palpable cervical lymph nodes were present in four adenocarcinoma cases, and the 201 T1 scan revealed the presence of metastatic nodes. (184)

Tellurium

Auto-Immune Response of Tellurium

Compounds containing tellurium show efficacy in preventing autoimmune reactions (185). AS101, a small, non-toxic tellurium compound, has anti-inflammatory and anti-autoimmune properties in patients with a variety of experimental autoimmune diseases(186). Multiple multifunctional activities of AS101 mediate its anti-autoimmune properties. These activities include: A) inhibiting Th17/IL-17 function; B) redox-modulating specific leukocyte integrins (α4β1 and α4β7) and enabling their inhibition; C) restoring the Treg population; and D) inducing IL-2 production, which in turn affects the Th17/Treg balance (187). Tellurium-based compounds could be a promising option for the treatment of autoimmune diseases, as indicated by AS101's anti-autoimmune activities (188).

Sulphur

Anti-Cancer Agent

In experimental animals, compounds were found to inhibit the metastasis of tumour cells, possibly because stem cells are immunostimulants. Currently unknown are the mechanisms of action of sulfur-containing compounds in immunostimulants (189).

Intestinal Antiseptic

It is worth considering whether the use of some sulphides, such as sulphuretted hydrogen, as intestinal antiseptics in the form of natural mineral waters, can account for the undeniable benefits often obtained from internal use of the sulphurous waters of Harrogate, Llandrindod, Aix, and many other spas more rationally than purgation alone (190). Since the sulphides are typically taken on an empty stomach, their potent form enters the intestine without breaking down due to the large amount of water in which they are dissolved, which reduces their local irritant action (191).

Arsenic

Anti-Cancer Agent

Currently, organic arsenicals are being investigated for possible medical applications. Human cancer cell lines HL-60 (leukemia), SGC 7901 (gastric cancer), and MCF-7 (breast cancer) were used to test the antitumor activity of several synthetic organ arsenicals (192). With IC50 values of 0.77 μM and 0.51 μM, respectively, 2-methoxy-4-((4-(oxoarsanyl) phenyl) imino) methyl) phenol ($C_{14}H_{12}AsNO_3$) showed the greatest growth inhibition of HL-60 cells. Both caused oxidative stress in HL-60 cells, which led to apoptosis (193).

To Treat Trypanosomiasis
French scientist Antoine Béchamp (1816–1908) created atoxyl, the first synthetic organ arsenic drug, in 1905 to treat human trypanosomiasis. Atoxyl was the first tropical medicine to be discovered (194).

Treat Syphilis
Compound 606, also known as the silver bullet Salvarsan, was the first successful chemotherapeutic medication for the treatment of syphilis (195). Arsphenamine was the 606th aromatic arsenical (196).

Other Elements
Flerovium, lead, livermorium, moscovium, nihonium, oganesson, polonium and tennessine are under research and are being studied for their therapeutic usage.

Conclusion
This articles reviews P-block elements that are used widely for the treatment of various ailments, but scientifically few of them were screened out, A broad spectrum of compounds containing main group elements and transition metals have been analyzed for their potential anti-tumor, anti-bacterial, and anti-fungal activity. Despite tremendous advancements in the exploration of the potency of p-block elements, most of them are still being analyzed for their therapeutic potential, continuous efforts are still in progress in search of newer therapeutic candidates. Thus, scientific studies should be conducted to investigate the unexploited potential of p-block elements.

Abbreviations
Mic-90=minimal inhibitory concentration, inhibiting 50% and 90%, BSS=Bernard-Soulier syndrome, CBS=Corticobasal syndrome, Nd: YAG=Neodymium-doped Yttrium Aluminum Garnet, CRP=C-reactive protein, U-2 OS=Human osteosarcoma, OGD= Oesophago Gastro Duodenoscopy, MCAO/R]=middle cerebral artery occlusion/reperfusion, EBRT external beam radiation therapy, LLLT=low-level laser therapy, HL-60=human leukemia cell line, Th17/Treg=Regulatory T cells (Tregs) and T helper 17 (Th17)), GABA=Gamma-aminobutyric acid, PSMA= prostate-specific membrane antigen.

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