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## Biological Activity of Organotin Steroids – A Brief Review

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**Abstract** Organotin steroids (OS) represent an interesting class of biologically active hormones. Currently, more than 100 OS have been synthesized, and many are widely used in medical practice, including medicine and pharmacology. We also used an algorithm that works with a PASS programme containing approximately one million chemical structures and approximately 8,000 validated biological activities and allows you to calculate the predicted activity from the chemical structure of the steroidal molecule. The biological activity and structures for this group of OS is presented in this paper. The most characteristic biological activities for OS were antineoplastic, anti-metastatic, anti-hypercholesterolemic and anticancer activities.

**Keywords** Organotin steroids, activities, anticancer, SAR, PASS

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### Introduction

Bioorganometallic chemistry is an area at the intersection of many areas of science and the medicinal chemistry and pharmaceutical industry, and above all, medicine, pharmacology, organic and inorganic chemistry [1].

Stannans or organotin compounds are chemical compounds of tin (Sn), in which there is a C-Sn bond and related components [2-3]. For the first time stannans were synthesized by Edward Frankland and later by Carl Jacob Löwig in 1850s [4-5]. The field of application of organotin compounds is the organic synthesis of many organometallic components in the industry, as well as the use of organotin compounds in medicine and pharmacology, which are toxic. Alkyl stannans are potent bactericides and fungicides and are therefore not widely used in agriculture and related fields [6-8]. Many compounds of organotin compounds show anticancer and anti-tuberculosis properties [9-10].

As already proved by numerous works, there is a relationship between structure and activity, and this principle is called SAR (Structure-Activity-Relationship). We used the computer program PASS, containing about one million chemical compounds and more than 8,000 biological activities, and calculated the biological activity of different natural and/or synthetic compounds [11-13]. PASS predictions are based on SAR analysis of the training set consisting of more than one million drugs, drug candidates and lead compounds. The algorithm of PASS practical utilization is described in detail in several publications [14-16].

This review is devoted to an interesting topic, i.e., organotin steroids and their biological activities.

### Biological Activities of Organotin Steroids

Steroids belong to the class of natural lipids, which are produced by microorganisms [17-19], plants [20], animals [21], marine algae and invertebrates [22-24]. Steroids and their derivatives have a huge number of diverse structures and have a wide range of biological activities [25].



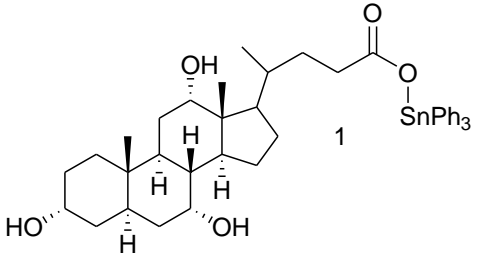
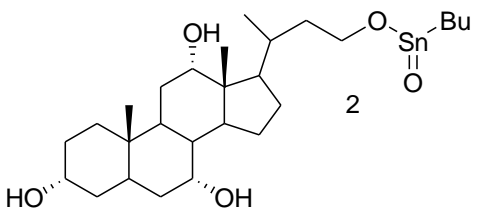
Concept organometallic steroids were introduced in the mid-1950s by a few groups of scientists [26-27]. We selected 20 stable OS, which are interesting from the point of view of medicine and pharmacology and for the pharmaceutical industry [1]. Many OS show anti-tumour, antiviral and antibacterial activity [6,9, 28-29].

Organotin steroids are a unique class of chemical compounds that are not found in nature, and only synthesized molecules that have a huge variety of chemical structures are known [1,28-29]. OS and organometalloid steroids are widely used in research and the medical and pharmaceutical industries [30-33].

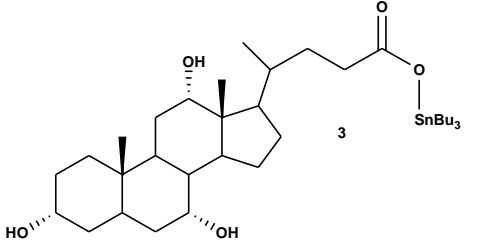
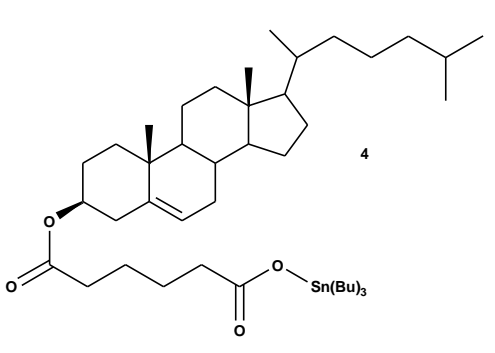
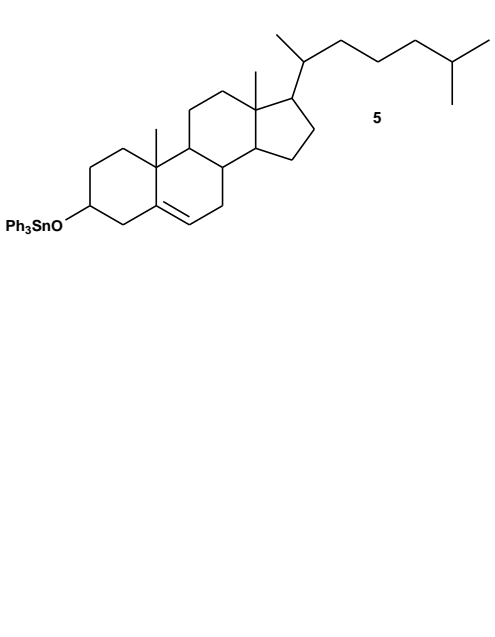
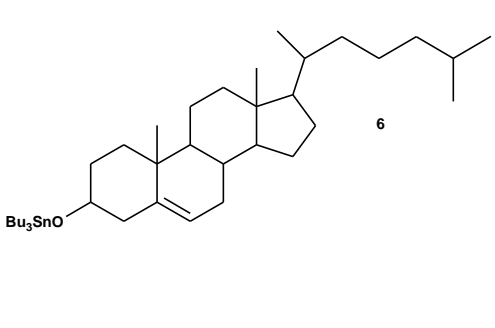
The organotin steroids (**1-20**) were synthesized using various organotin reagents with steroids [1,6,9,28,29]. The obtained synthetic steroids inhibit the growth of malignant tumors, and are also used as insecticides, larvicides, bactericides and fungicides [9,10,28,29,33-36].

Table 1 shows the structures and biological activity of organotin steroids (**1-20**). According to the results obtained, biological activity for almost all tin steroids is anticancer activity, both confirmed and predicted. Other predicted biological activities for all organotin steroids see in Table 1.

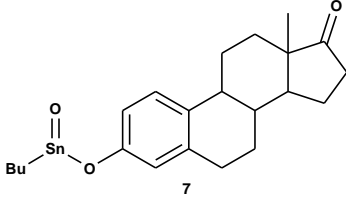
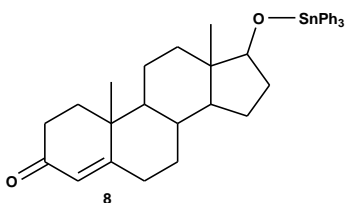
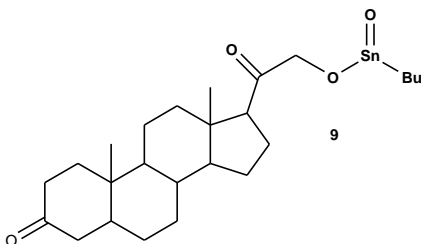
**Table 1:** Biological activities of organotin steroids (**1-20**)

Organotin steroids	Activity reviewed	Activities confirmed (Pa)*	Additional predicted activities (Pa)*
 <p>1</p>	Anticancer	Antineoplastic (0,847) Antimetastatic (0,576)	Choleretic (0,895) Biliary tract disorders treatment (0,825) Antieczematic (0,819) Antihypercholesterolemic (0,803) Laxative (0,764) Hepatic disorders treatment (0,716) Respiratory analeptic (0,687) Antibacterial (0,677) Erythropoiesis stimulant (0,665) Dermatologic (0,654) Antiinflammatory (0,639) Antifungal (0,622)
 <p>2</p>	anticancer	Antineoplastic (0,790) Antimetastatic (0,581)	Choleretic (0,894) Biliary tract disorders treatment (0,838) Antieczematic (0,831) Antihypercholesterolemic (0,828) Antiinflammatory (0,828) Respiratory analeptic (0,807) Laxative (0,760) Immunosuppressant (0,753) Hepatic disorders treatment (0,734) Antifungal (0,708) Dermatologic (0,706) Antipsoriatic (0,678) Antibacterial (0,662)
	Anticancer	Antineoplastic (0,723) Antimetastatic (0,575)	Choleretic (0,895) Antieczematic (0,831) Biliary tract disorders treatment (0,824) Antihypercholesterolemic (0,790) Antibacterial (0,750) Laxative (0,728)

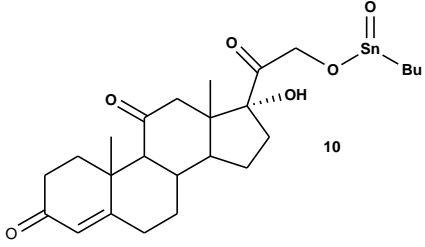
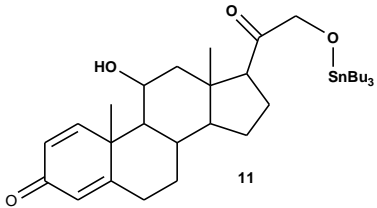
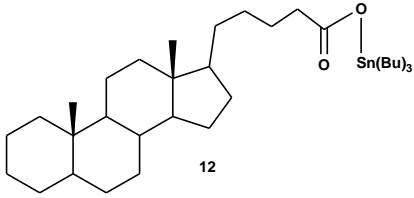
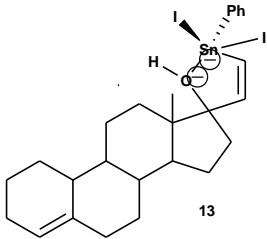


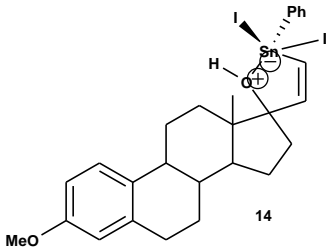
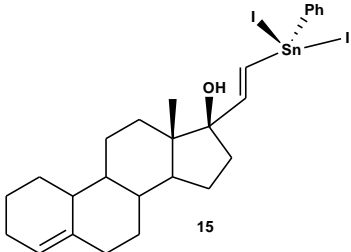
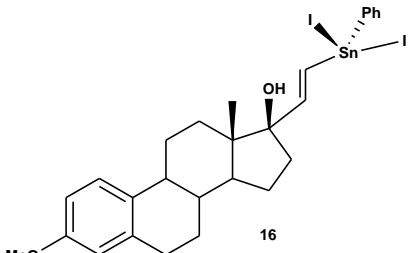
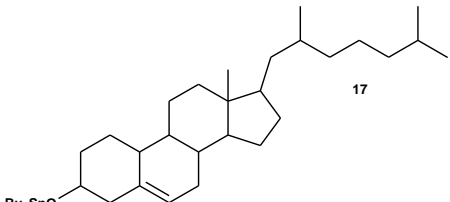
 <p>3</p>			Hepatic disorders treatment (0,707) Immunosuppressant (0,693) Antiinflammatory (0,691) Hypolipemic (0,689) Antifungal (0,673)
 <p>4</p>	Anticancer Antibacterial	Antineoplastic (0,748) Antimetastatic (0,510) Antibacterial (0,685)	Antihypercholesterolemic (0,895) Antieczematic (0,812) Immunosuppressant (0,775) Respiratory analeptic (0,752) Antiinflammatory (0,698) Dermatologic (0,683) Prostate disorders treatment (0,664) Antifungal (0,649) Cholesterol synthesis inhibitor (0,645)
 <p>5</p>	Anticancer Antibacterial	Antineoplastic (0,866) Prostatic (benign) hyperplasia treatment (0,653) Antimetastatic (0,548) Antineoplastic (pancreatic cancer) (0,502) Prostate cancer treatment (0,500) Antibacterial (0,573)	Antihypercholesterolemic (0,907) Respiratory analeptic (0,847) Antieczematic (0,822) Anesthetic general (0,804) Antipruritic (0,766) Dermatologic (0,747) Antiinflammatory (0,732) Immunosuppressant (0,715) Bone diseases treatment (0,697) Antiosteoporotic (0,682) Cholesterol synthesis inhibitor (0,627) Hepatoprotectant (0,611)
 <p>6</p>	Anticancer	Antineoplastic (0,799) Prostatic (benign) hyperplasia treatment (0,633) Antimetastatic (0,540)	Antihypercholesterolemic (0,906) Antieczematic (0,830) Respiratory analeptic (0,815) Anesthetic general (0,804) Immunosuppressant (0,781) Antipruritic (0,767) Antiinflammatory (0,762) Dermatologic (0,736) Bone diseases treatment (0,663) Antifungal (0,662) Antiosteoporotic (0,652)
	Anticancer	Antineoplastic (0,804) Antineoplastic	Antiseborrheic (0,902) Ovulation inhibitor (0,901) Alopecia treatment (0,764)



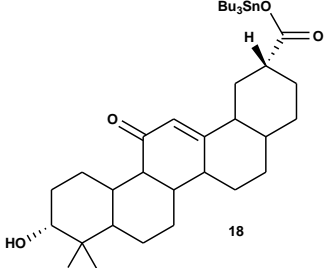
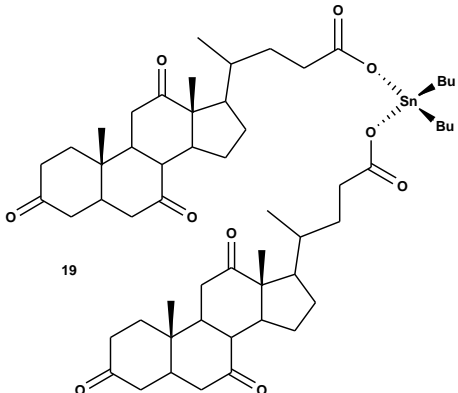
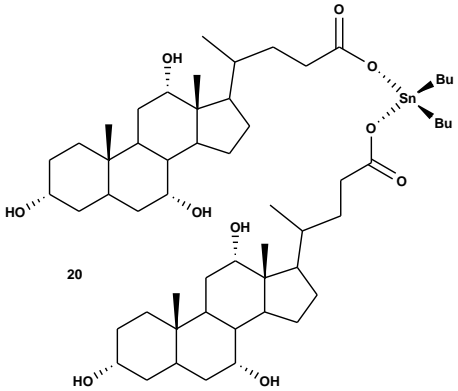
 <p>7</p>		(breast cancer) (0,681) Prostatic (benign) hyperplasia treatment (0,580)	Male reproductive disfunction treatment (0,716) Cardiovascular analeptic (0,666) Menopausal disorders treatment (0,663) Antiinflammatory (0,645) Immunosuppressant (0,640) Antipruritic (0,593) Dermatologic (0,583) Antiosteoporotic (0,579)
 <p>8</p>	Anticancer Antibacterial	Antineoplastic (0,906) Antineoplastic (breast cancer) (0,637) Prostatic (benign) hyperplasia treatment (0,627) Antineoplastic (sarcoma) (0,624) Antineoplastic (renal cancer) (0,562) Prostate cancer treatment (0,550) Antineoplastic (pancreatic cancer) (0,541) Antibacterial (0,441)	Antiseborrheic (0,878) Ovulation inhibitor (0,840) Alopecia treatment (0,812) Antiinflammatory (0,750) Anesthetic general (0,689) Dermatologic (0,674) Antipruritic (0,674) Neuroprotector (0,671) Menopausal disorders treatment (0,666) Male reproductive disfunction treatment (0,650) Respiratory analeptic (0,651) Bone diseases treatment (0,641) Antiosteoporotic (0,623) Antiacne (0,519)
 <p>9</p>	Anticancer	Antineoplastic (0,741) Prostatic (benign) hyperplasia treatment (0,641)	Anesthetic general (0,850) Antiseborrheic (0,828) Antiinflammatory (0,765) Immunosuppressant (0,725) Dermatologic (0,705) Antipruritic (0,705) Antieczematic (0,723) Erythropoiesis stimulant (0,686) Menopausal disorders treatment (0,598) Antiacne (0,549)



 <p>10</p>	Not studied		Antiinflammatory (0,917) Anesthetic general (0,872) Antiseborrheic (0,831) Antineoplastic (0,828) Respiratory analeptic (0,827) Antipruritic (0,808) Immunosuppressant (0,798) Ovulation inhibitor (0,794) Muscular dystrophy treatment (0,784) Prostate disorders treatment (0,708) Dermatologic (0,693)
 <p>11</p>	Not studied		Antiinflammatory (0,920) Antipruritic (0,812) Immunosuppressant (0,786) Allergic conjunctivitis treatment (0,765) Antineoplastic (0,761) Antiallergic (0,760) Antipruritic, allergic (0,710) Prostate disorders treatment (0,701) Dermatologic (0,697) Antieczemetic (0,648)
 <p>12</p>	Not studied		Antieczemetic (0,807) Prostate disorders treatment (0,683) Cytoprotectant (0,683) Antiosteoporotic (0,612) Erythropoiesis stimulant (0,609) Antibacterial (0,592) Antineoplastic (0,629) Immunosuppressant (0,577) Prostatic (benign) hyperplasia treatment (0,568) Antipruritic (0,541) Menopausal disorders treatment (0,528) Ovulation inhibitor (0,525)
 <p>13</p>	Anticancer	Antineoplastic (0,946) Prostatic (benign) hyperplasia treatment (0,643) Antineoplastic (breast cancer) (0,630)	Antiseborrheic (0,822) Prostate disorders treatment (0,748) Alopecia treatment (0,720) Antiinflammatory (0,711) Postmenopausal disorders treatment (0,677) Antisecretoric (0,672) Dermatologic (0,665) Gynecological disorders treatment (0,553) Contraceptive (0,509) Diuretic (0,508) Erythropoiesis stimulant (0,505)

<p>0,505</p>  <p>14</p>	Anticancer	<p>Antineoplastic (0,905) Antineoplastic (breast cancer) (0,566) Prostatic (benign) hyperplasia treatment (0,532)</p>	<p>Antiseborrheic (0,908) Alopecia treatment (0,696) Prostate disorders treatment (0,666) Antiinflammatory (0,640) Antisecretoric (0,622) Genital warts treatment (0,611) Dementia treatment (0,519) Antiosteoporotic (0,509) Antipruritic, allergic (0,536)</p>
 <p>15</p>	Anticancer	<p>Antineoplastic (0,996) Antineoplastic (breast cancer) (0,625)</p>	<p>Antiseborrheic (0,754) Ovulation inhibitor (0,721) Prostate disorders treatment (0,647) Antiosteoporotic (0,599) Bone diseases treatment (0,561) Dermatologic (0,561) Menopausal disorders treatment (0,518)</p>
 <p>16</p>	Anticancer	<p>Antineoplastic (0,996) Antineoplastic (breast cancer) (0,577)</p>	<p>Antiseborrheic (0,879) Ovulation inhibitor (0,689) Prostate disorders treatment (0,582) Genital warts treatment (0,538) Menopausal disorders treatment (0,532) Allergic conjunctivitis treatment (0,527) Antiosteoporotic (0,521)</p>
 <p>17</p>	Anticancer	<p>Antineoplastic (0,774) Prostatic (benign) hyperplasia treatment (0,634) Antineoplastic (breast cancer) (0,512)</p>	<p>Antiosteoporotic (0,755) Prostate disorders treatment (0,718) Antieczematic (0,707) Immunosuppressant (0,698) Antiseborrheic (0,643) Antihypercholesterolemic (0,630) Antiinflammatory (0,622) Antisecretoric (0,580) Antibacterial (0,544) Hypolipemic (0,542) Menopausal disorders treatment (0,529) Antiacne (0,522)</p>
	Anticancer	Antineoplastic (0,704)	<p>Antieczematic (0,630) Immunosuppressant (0,580) Antibacterial (0,566) Prostate disorders treatment (0,540) Antiinflammatory (0,539) Dermatologic (0,532)</p>



 <p>18</p>			
 <p>19</p>	Anticancer	Antineoplastic (0,799) Prostatic (benign) hyperplasia treatment (0,520)	Choleretic (0,843) Antieczematic (0,794) Antiinflammatory (0,720) Prostate disorders treatment (0,651) Dermatologic (0,651) Immunosuppressant (0,602) Laxative (0,567) Antipruritic (0,525) Male reproductive dysfunction treatment (0,501)
 <p>20</p>	Anticancer	Antineoplastic (0,810) Antimetastatic (0,575)	Choleretic (0,895) Antieczematic (0,831) Biliary tract disorders treatment (0,824) Antiinflammatory (0,812) Antihypercholesterolemic (0,790) Laxative (0,728) Antipruritic (0,727) Hepatoprotectant (0,714) Immunosuppressant (0,693) Hypolipemic (0,689) Antifungal (0,673) Respiratory analeptic (0,626) Proliferative diseases treatment (0,617) Antipsoriatic (0,613) Erythropoiesis stimulant (0,612) Antibacterial (0,586) Prostate disorders treatment (0,584)

\* Only activities with Pa > 0.5 are shown

### Conclusion

In this review, we present the structures and biological activities of OS. The most characteristic biological activities for OS were antineoplastic, anti-metastatic, anti-hypercholesterolemic and anticancer activities. The biological activity for almost all of the organotin steroids is anticancer activity, which is both confirmed and predicted.

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### Competing Interests

Authors have declared that no competing interests exist.

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