



# Semantic Processing for Biomedical Knowledge Discovery

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National Library of Medicine

# Disclaimer

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# Overview

- Build on NLM resources
  - To provide enhanced access to biomedical text
- As an enabling technology for
  - Innovative information processing applications
- Interpret text as semantic predications
  - Computable knowledge
- Pilot study in biomedicine
  - Extendible to other domains

# Biomedical text: MEDLINE

- More than 23 million biomedical journal citations
  - Text: title and abstract
  - MeSH indexing
- Comprehensive repository of biomedical knowledge
- Access provided by document retrieval system
  - PubMed
- Technology: Manipulate text tokens
  - No access to meaning

# Semantic processing

- Manipulate information
  - Not just documents
- Bridge the gap between
  - Language (text)
  - Meaning
- Computable representation of meaning
  - Semantic predications
- More effective access to meaning in text

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**Semantic MEDLINE**

# Semantic MEDLINE

PubMed

MEDLINE citations

SemRep

Semantic predications

Automatic summarization

Graphical summary

Biomedical knowledge discovery

# SemRep: Extract predication

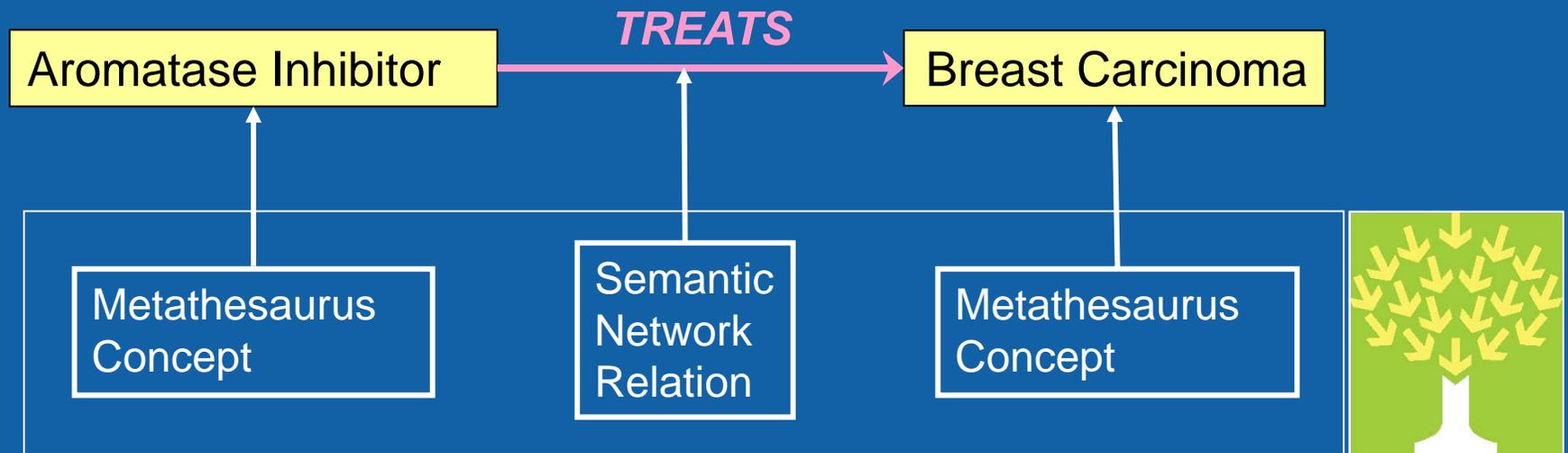
TI - Exemestane after non-steroidal aromatase inhibitors for post-menopausal women with advanced breast cancer. AB - A retrospective analysis was performed on 31 consecutive locally advanced or metastatic breast cancer patients who commenced exemestane 25mg/d orally following previous treatment with Tamoxifen and a non-steroidal third-generation aromatase inhibitor (AI). Patients were seen 3 monthly until clinical or radiological

## ... Exemestane after non-steroidal aromatase inhibitor for post-menopausal women with advanced breast cancer

Analysis of aromatase inhibitors and tamoxifen in the treatment of hormone-dependent breast cancer. Within the past 2 years three separate groups reported marked improvements in relapse-free survival when trastuzumab was added to adjuvant chemotherapy in patients with HER2-overexpressing breast cancer. Notwithstanding the significance of this molecular target, the discovery of the estrogen receptor (ER) may be of even greater importance. Although tamoxifen has long been considered the hormonal therapy of choice for patients with estrogen-responsive breast cancer, accumulating clinical data suggest the new generation of aromatase inhibitors (AIs) is more effective and less toxic. With the availability of new information, guidelines have been updated and reformulated regarding the use of AIs as first-line hormonal therapy in postmenopausal women with ER-positive breast cancer. This paper, a product of the ongoing advances in oncology, incorporates two distinct, yet important, features of oncology; first, clinical concepts related to hormone-dependent breast cancer and second, pharmacoeconomic evaluation of the antiestrogen tamoxifen and the new generation of antiaromatase agents. TI - An alpha-fetoprotein-derived peptide reduces the uterine hyperplasia and increases the antitumour effect of tamoxifen. AB - Tamoxifen (Tam) is effective for the treatment and prevention of breast cancer. However, it has toxic drawbacks and has limited-duration utility because, over time, human tumours become refractory to Tam. Recently, a new nontoxic peptide, alpha-fetoprotein-derived peptide (AFPep) has been proposed for the treatment and prevention of breast cancer. The purpose of this paper is to determine whether combining AFPep with Tam would increase efficacy and reduce toxicity in experimental models of breast cancer. Low doses of AFPep and Tam were more effective in combination than either agent alone against breast cancer growth in cell culture, in tumour-xenografted mice, and in carcinogen-exposed rats. alpha-Fetoprotein-derived peptide interfered with Tam-induced uterine hyperplasia in immature mice, and showed no toxic effects. Unlike Tam, AFPep did not inhibit binding of oestradiol (E(2)) to oestrogen receptor (ER). Thus, these two agents utilise different mechanisms to interfere with ER functionality, yet work cooperatively to reduce breast cancer growth and alleviate Tam's troubling toxicity of uterine hyperplasia and appear to be a rational combination for the treatment of ER-positive breast cancer. British Journal of Cancer (2007) 97, 327-333. TI - Adjuvant trastuzumab in the treatment of HER-2-positive early breast cancer: a meta-analysis of published randomized trials. AB - ABSTRACT: BACKGROUND: Breast cancer is the most common cancer in women in the U.S. and western Europe. Amplification of the her-2/neu gene occurs in approximately 25% of invasive ductal carcinomas of the breast. The first HER-2/neu-targeted approach to reach the clinic was trastuzumab, a humanized monoclonal antibody directed against the extracellular domain of the HER-2/neu protein. Trastuzumab therapy prolongs the survival of patients with metastatic HER-2/neu-overexpressing breast cancer when combined with chemotherapy and has recently been demonstrated to lead to dramatic improvements in disease-free survival when used in the adjuvant therapy setting in combination with or following chemotherapy. Here, we performed a meta-analysis of completed clinical trials of adjuvant trastuzumab in the adjuvant setting. Survival, recurrence, brain metastases, cardiotoxicity and directions for future research are discussed. METHODS: A meta-analysis of randomized controlled trials (RCT) was performed comparing adjuvant trastuzumab treatment for HER2-positive early breast cancer (EBC) to observation. The MEDLINE, EMBASE, CANCELIT and Cochrane Library databases, and abstracts published in the annual proceedings were systematically searched for evidence. Relevant reports were reviewed by two reviewers independently and the references from these reports were searched for additional trials, using guidelines set by QUOROM statement criteria. RESULTS: Pooled results from that five randomized trials of adjuvant Trastuzumab showed a significant reduction of mortality (p0.00001), recurrence (p0.00001), metastases rates (p0.00001) and second tumors other than breast cancer (p=0.007) as compared to no adjuvant Trastuzumab patients. There were more grade III or IV cardiac toxicity after trastuzumab (203/4555 = 4.5%) versus no trastuzumab (86/4562 = 1.8%). The likelihood of cardiac toxicity was 2.45-fold higher (95% CI 1.89 - 3.16) in trastuzumab arms, however that result was associated with heterogeneity. The likelihood of brain metastases was 1.82-fold higher (95% CI 1.16 - 2.85) in patients who received trastuzumab. CONCLUSION: The results from this meta-analysis are sufficiently compelling to consider 1 year of adjuvant trastuzumab treatment for women with HER-2-positive EBC based on the risk: benefit ratio demonstrated in these studies. Adequate assessment of HER-2/neu status is critical, and careful cardiac monitoring is warranted because of cardiac toxicity. Clinical trials should be designed to answer unsolved questions. TI - Prognostic and Predictive Value of Centrally Reviewed Expression of Estrogen and Progesterone Receptors in a Randomized Trial Comparing Letrozole and Tamoxifen Adjuvant Therapy for Postmenopausal Women With Early Breast Cancer: Results From the BIG 1-98 Collaborative Groups. AB - PURPOSE: To evaluate locally versus centrally assessed estrogen (ER) and progesterone (PgR) receptor status and the impact of PgR on letrozole adjuvant therapy compared with tamoxifen in postmenopausal women with early breast cancer. PATIENTS AND METHODS: Breast International Group (BIG) 1-98 randomly assigned 8,010 patients to four arms comparing letrozole and tamoxifen with sequences of each agent. The Central Pathology Office received material for 6,549 patients (82%), of which 79% were assessable (6,291 patients). Prognostic and predictive value of both local and central hormone receptor expression on disease-free survival (DFS) were evaluated among 3,650 assessable patients assigned to the monotherapy arms. Prognostic value and the treatment effect were estimated for centrally assessed ER and PgR expression levels using the Subpopulation Treatment Effect Pattern Plot. RESULTS: Central review confirmed 97% of tumors as hormone receptor-positive (ER and/or PgR >=10%). Of 105 tumors locally ER-negative, 73 were found to have more than 10% positive cells, and eight had 1% to 9%. Of 6,100 tumors locally ER positive, 66 were found to have no staining, and 54 had only 1% to 9%. Discordance was more marked for PgR than ER. Patients with tumors reclassified centrally as ER-negative, or as hormone receptor-negative, had poor DFS. Centrally assessed ER and PgR showed prognostic value. Among patients with centrally assessed ER-expressing tumors, letrozole showed better DFS than tamoxifen, irrespective of PgR expression level. CONCLUSION: Central review changed the assessment of receptor status in a substantial proportion of patients, and should be performed whenever possible in similar trials. PgR expression did not affect the relative efficacy of letrozole over tamoxifen. TI - Drug insight: breast cancer prevention and tissue-targeted hormone replacement therapy. AB - The first-generation selective estrogen receptor modulator (SERM) tamoxifen has been the mainstream hormone therapy in breast cancer. Tamoxifen benefits all stages of the disease, but its use increases the risk of uterine cancer and thromboembolic events and it can only be administered for 5 years. Aromatase inhibitors are superior to tamoxifen at advanced stages of disease and as adjuvants; however, because they increase fractures, aromatase inhibitors are unlikely to be used to prevent disease. Raloxifene, a second-generation SERM, leads, like tamoxifen, to approximately 50% fewer cases of invasive breast cancer in high risk women, with a lower incidence of thromboembolic events. Several other SERMs are in development to improve tissue specificity, efficacy and tolerance. Raloxifene shows protection against vertebral fractures similar to bisphosphonates; however, no significant effect has been observed on nonvertebral fractures. Many SERMs are in development for prevention and treatment of osteoporosis. As breast cancer metastasizes early and advanced disease cannot be cured, prevention is essential. To avoid the concerns about the use of traditional hormone replacement therapy, dehydroepiandrosterone—a tissue-targeted precursor of sex steroid formation—offers hope of a physiological tissue-targeted hormone replacement that, combined with a SERM, would simultaneously prevent breast and uterine cancer. TI - Comparative economic analysis of aromatase inhibitors and tamoxifen in the treatment of hormone-dependent breast cancer. AB - Within the past 2 years three separate groups reported marked improvements in relapse-free survival when trastuzumab was added to adjuvant chemotherapy in patients with HER2-overexpressing breast cancer. Notwithstanding the significance of this molecular target, the discovery of the estrogen receptor (ER) may be of even greater importance. Although tamoxifen has long

# SemRep: Predication structure

... Exemestane after non-steroidal aromatase inhibitor for post-menopausal women with advanced breast cancer



Unified Medical Language System

# SemRep: Several evaluations

- Focused on biomedical subdomains, e.g.
  - Clinical treatment, genetic etiology of disease, pharmacogenomics
- Focused on linguistic structure, e.g.
  - Hypernymic predications, comparatives, nominalizations
- Overall
  - Precision is around 75% (lower for molecular biology)
  - Recall is around 60%

# Predication database: SemMedDB

- Processed all of MEDLINE
  - More than 23 million citations
  - Titles and abstracts
- SemRep predications extracted
  - More than 68 million predications (through 11/30/2013)
- Made available to the research community
  - MySQL database
  - RDF triples (Olivier Bodenreider and YarcData)

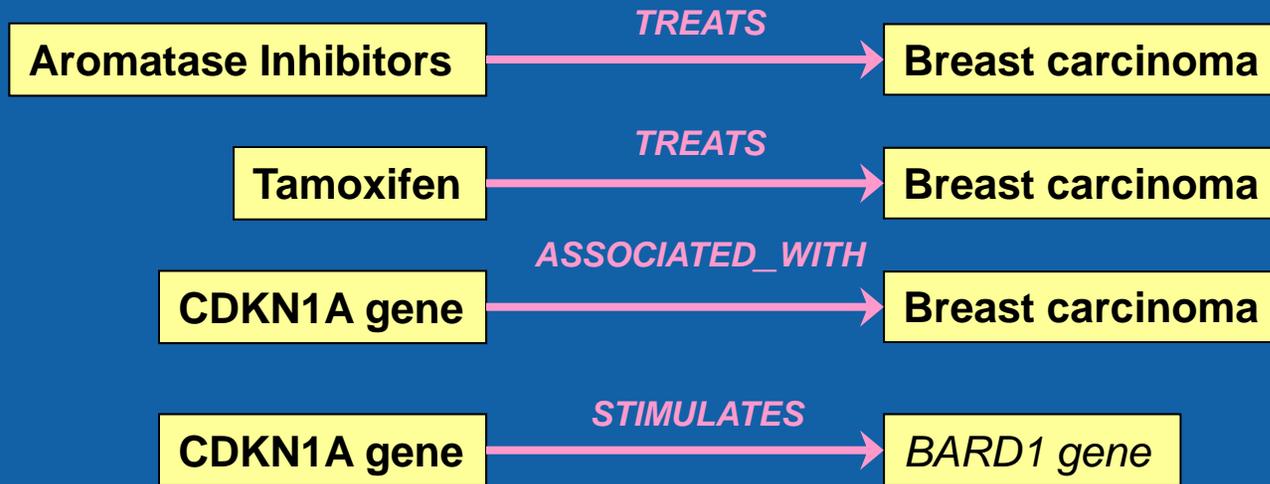


# SemMed: Summarization



- Specify a topic
- Retain predications on the topic using a schema
- Eliminate uninformative predications
- Retain most frequent predications

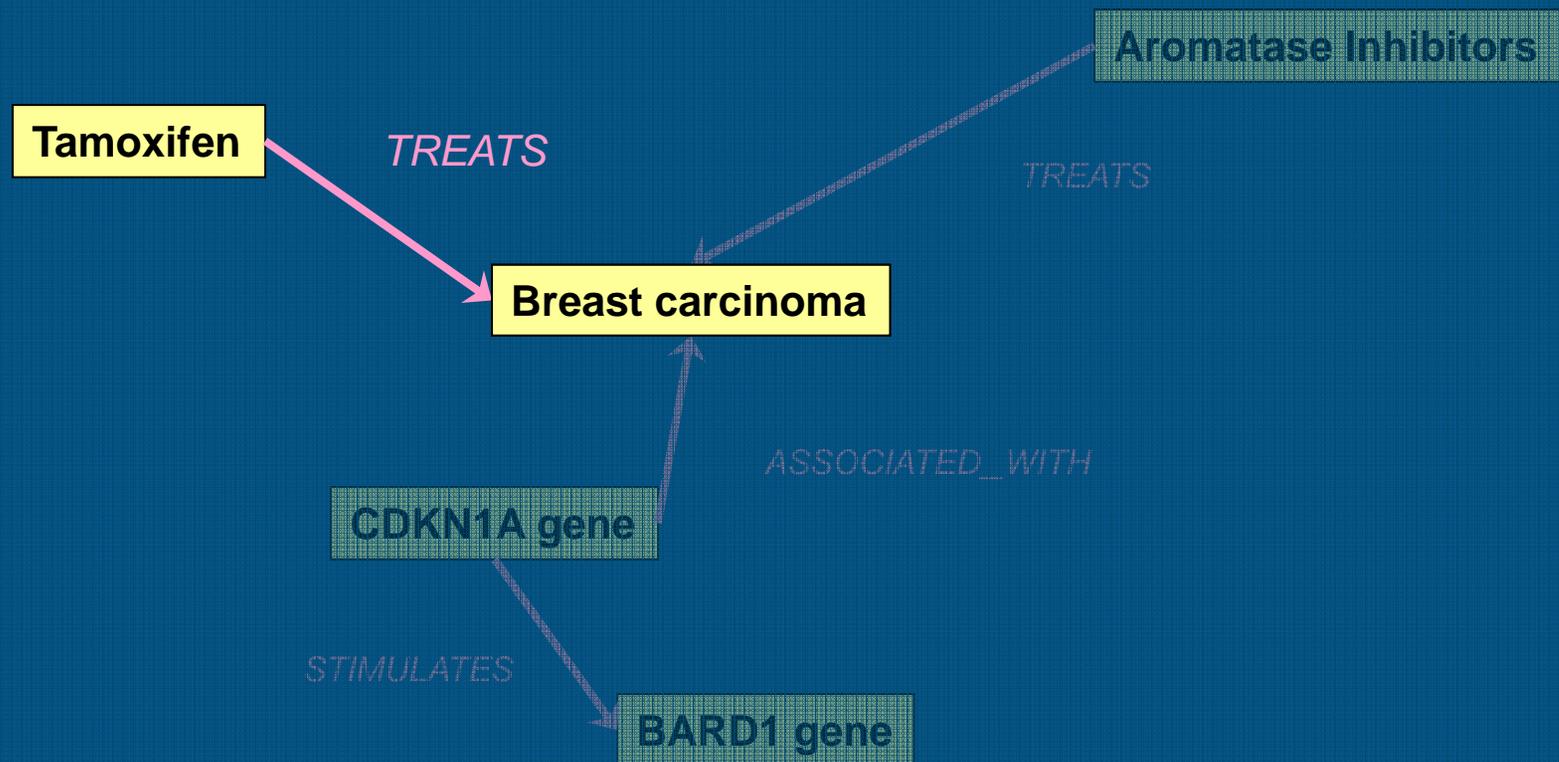
# Summarized predications



... ..



# SemMed: Visualization

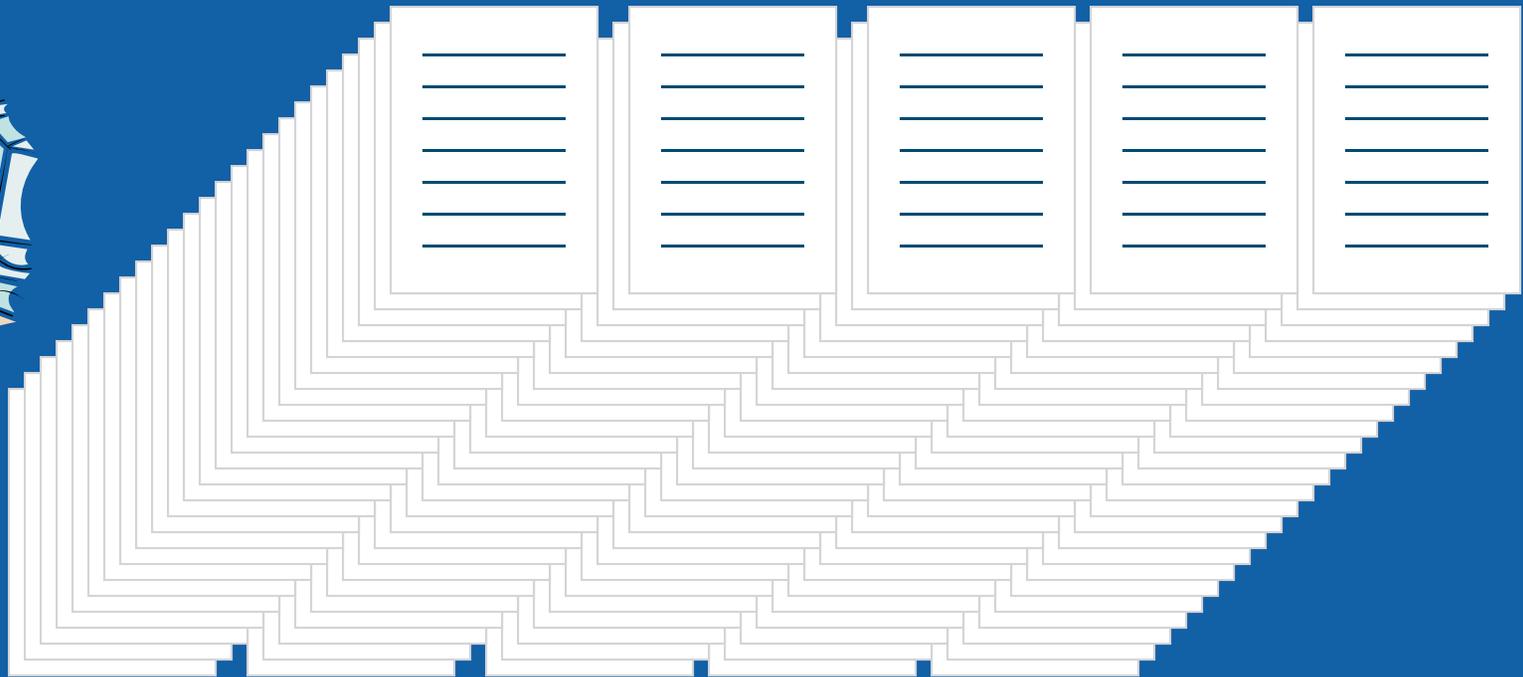


# SemMed: Link to text

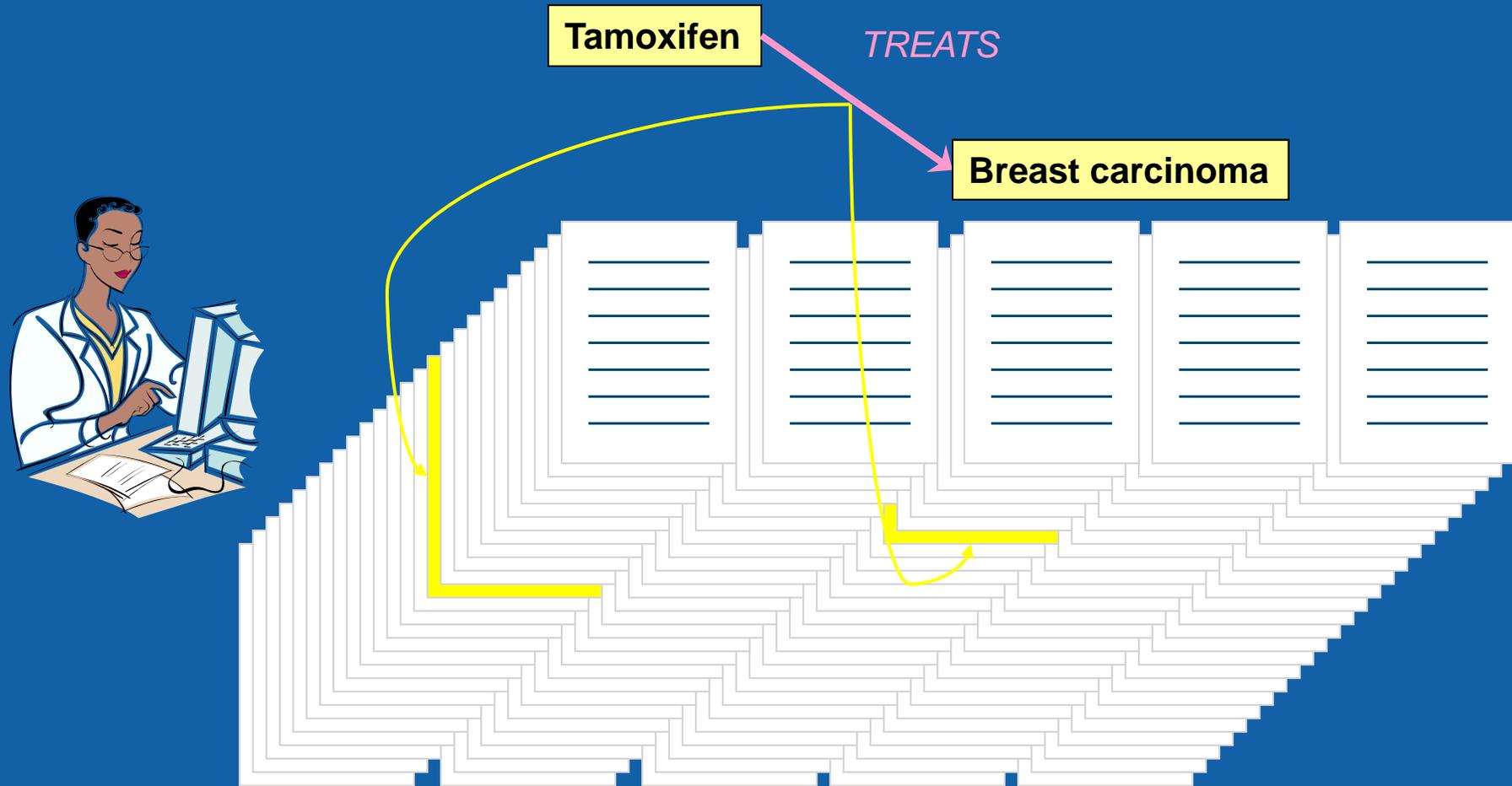
Tamoxifen

TREATS

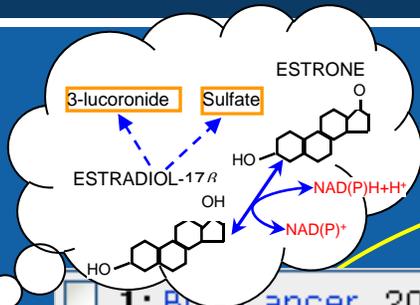
Breast carcinoma



# SemMed: Link to text



# SemMed: Research



**Tamoxifen**

*TREATS*

**Breast carcinoma**

1: [Breast Cancer](#). 2007 Aug 6;97(3):327-33. Epub 2007 Jul 17.

**An alpha-fetoprotein-derived peptide reduces the uterine hyperplasia and increases the antitumour effect of tamoxifen.**

[Andersen TT](#), [Georgekutty J](#), [Defreest LA](#), [Amaratunga G](#), [Narendran A](#), [Lemanski N](#), [Jacobson HI](#), [Bennett JA](#).

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However, it has toxic drawbacks and has limited-duration utility because, over time, human tumours become refractory to Tam. Recently, a new nontoxic peptide, alpha-fetoprotein-derived peptide (AFPep) has been proposed for the treatment and prevention of breast cancer. The purpose of this paper is to determine whether combining AFPep with Tam would increase efficacy and reduce toxicity in experimental models of breast cancer. Low doses of AFPep and Tam were more effective in combination than either agent alone against breast cancer growth in cell culture, in tumour-xenografted mice, and in carcinogen-exposed rats. alpha-Fetoprotein-derived peptide interfered with Tam-induced uterine hyperplasia in immature mice, and showed no



# Characteristics

- Provides an overview of research
  - Letting you make salient connections
  - You would likely miss without it
- Can help guide your thinking
- About how to solve a problem
  - Before you spend time garnering supportive details

# Exploiting Semantic MEDLINE

- Portfolio analysis of NIH grant applications [support from NIH/OD]
- Finding literature to support clinical practice guideline development [support from NHLBI]
- Ported to YarcData Urika graph machine
  - 2.2 billion RDF triples (MEDLINE and predications)
  - Big Data initiative
- Facilitate biomedical basic research

# Semantic MEDLINE for Research

- Literature-based discovery (LBD)
  - Hypothesis generation
- Discovery browsing
  - Get on top of a topic
- Trends
  - Discern trends: Where is research headed?
  - Guide trends: Where should it be headed?

# Use case: Cancer therapy

- With some exceptions, therapy is not effective
  - Has not progressed significantly in 60 years
- Scientific basis
  - Traditionally – cancer cells
  - More recently – non-cancer cells
- Inflammation and cancer
  - Connection noted in 1863 (Virchow)
  - But not exploited until recently
- Goal: look for trends in cancer immunotherapy

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