جامعة القاهرة

كلية الصيدلة

النانو تكنولوجى

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جامعة القاهرة

المقدمة

"هل تساءلت يوماً عما سيمكن للإنسان أن يفعله في حال السيطرة على الذرة الواحدة وتحريكها بحرية وسهولة؟"

جاء هذا على لسان العالم فينمان عندما أعلن عن ظهور تقنية حديثة سميت بالتقنية النانو نية أو النانوتكنولوجي .

لقد تنبأ العلماء بمستقبل واعد لهذه التقنية التي بدأت بشكل حقيقي عام ١٩٩٠ والتي باتت الدول الصناعية تضخ الملايين من الدولارات من أجل تطويرها وقد وصل تمويل اليابان لدعم بحوث النانوتكنولوجي لهذا العام إلى بليون دولار أما في الولايات المتحدة فهناك ٤٠.٠٠٠ عالم أمريكي لديهم المقدرة على العمل في هذا المجال ، وتقدّر الميزانية الأمريكية المقدمة لهذا العلم بتريليون دولار حتى عام٢٠١٥.

فما هو هذا العلم الذي يتوقع له أن يغزو العالم بتطبيقاته التي قاربت الخيال ؟

النانوتكنولوجي هو الجيل الخامس الذي ظهر في عالم الإلكترونيات وقد سبقه أولاً الجيل الأول الذي استخدم المصباح الإلكتروني (Lamp) بما فيه التلفزيون ، والجيل الثاني الذي استخدم جهاز الترانزيستور ، ثم الجيل الثالث من الإلكترونيات الذي استخدام الدارات التكاملية (IC) وهي عبارة عن قطعة صغيرة جداً قامت باختزال حجم العديد من الأجهزة بل رفعت من كفاءتها وعددت من وظائفه.

وجاء الجيل الرابع باستخدام المعالجات الصغيرة Microprocessor الذي أحدث ثورة هائلة في مجال الإلكترونيات بإنتاج الحاسبات الشخصية (Personal Computer) والرقائق الكومبيوترية السيليكونية التي أحدثت تقدماً في العديد من المجالات العلمية والصناعية فماذا عن الجيل الخامس ؟وهو ما صار يعرف باسم النانوتكنولو جي.

ما هو النانوتكنولوجي ؟

تطلق كلمة نانو باللغة الإنجليزية على كل ما هو ضئيل الحجم دقيق الجسم تعني هذه العبارة حرفياً تقنيات تصنع على مقياس النانومتر.

فالنانو هو أدق وحدة قياس مترية معروفة حتى الآن (نانو متر) ويبلغ طوله واحد من بليون من المتر أي ما يعادل عشرة أضعاف وحدة القياس الذرية المعروفة بالأنغستروم ، وحجم النانو أصغر بحوالي ٨٠٠٠٠ مرة من قطر الشعرة ، وكلمة النانو تكنولوجي تستخدم أيضاً بمعنى أنها تقنية المواد المتناهية في الصغر أو التكنولوجيا المجهرية الدقيقة . وقد بدأ مصطلح (تقنية النانو) ينتشر، في مجال الصناعات الإلكترونية.

خواص جزيئات النانو

عند المستوى الدقيق (النانو)، نجد أن الخواص الطبيعية والكيميائية والبيولوجية تختلف جوهرياً، وغالبا بشكل غير متوقع عن تلك المواد الكبيرة الموازية لها بسبب أن خواص الكمية الميكانيكية للتفاعلات الذرية يتم التأثير عليها بواسطة التغيرات في المواد على المستوى الدقيق. وفي الواقع أنه من خلال تصنيع أجهزة طبقا لمعيار النانومتر من الممكن السيطرة على الخصائص الجوهرية للمواد بما في ذلك درجة الانصهار والخواص المغناطيسية وحتى اللون بدون تغير التركيب الكيميائي لها.

النانو تكنولوجي تمكن من امتلاك الإمكانية لزيادة كفاءة استهلاك الطاقة،ويساعد في تنظيف البيئة،ويحل مشاكل الصحة الرئيسية،كما إنه قادر على زيادة الإنتاج التصنيعي بشكل هائل وبتكاليف منخفضة جداَ،وستكون منتجات النانوتكنولوجي أصغر .

تطبيقات النانو تكنولوجي في الطب:

تعد التطبيقات الطبية لهذه التكنولوجيا من أهم التطبيقات الواعدة على الإطلاق، فمن المحتمل الحصول على مركبات نانونية تدخل إلى جسم الإنسان وترصد مواقع

الأمراض وتحقن الأدوية وتأمر الخلايا بإفراز الهرمونات المناسبة وترمم الأنسجة .كما يمكن لهذه المركبات الذكية أن تحقن الأنسولين داخل الخلايا بالجرعات المناسبة أو تدخل إلى الخلايا السرطانية لتفجرها من الداخل و تدعى عندئذ **بالقنابل النانونية** والتي استطاعت أن تطيل عمر الفئران من ٤٣ يوم إلى ٣٠٠ يوم .

أما أجهزة الاستشعار النانونية فباستطاعتها أن تزرع في الدماغ لتمكن المصاب بالشلل الرباعي من السير.

كما تم الحصول على طاقم أسنان سيليكوني لا يزيد حجمه عن حجم الخلية يستطيع ابتلاع الكريات الحمراء وقضمها ثم إطلاقها مجدداً إلى الدم بمعدل عشر خلايا في الثانية ، ويمكن لطاقم الأسنان هذا أن يساعد على إدخال الأدوية أو الجينات إلى داخل الخلايا وبالتالي يعزز العلاج الخلوي المركز للكثير من الأمراض. ويتوقع الباحثون أن تؤدي هذه التكنولوجيا الجديدة إلى ثورة غير مسبوقة للتصدي للكائنات الدقيقة حيث يعتمد النانوبيوتكس (Nanobiotics) وهو البديل الجديد للمضادات الحيوية على الثقب الميكانيكي للخلايا الممرضة (الجراثيم أو الفيروسات) .

فالنانوبيوتكس هو ببتيد حلقي ذاتي التجمع ،ومُخَلّق صناعيا، من الممكن له أن يتجمع على هيئة أنابيب نانوتيوب (Nanotubes) أو دبابيس نانو نية متناهية في الصغر. فعند دخول ملايين من هذه الأنابيب اللزجة والمكونة من الببتيدات الحلقية داخل الجذر الهلامي للبكتريا فإنها تنجذب كيميائياً إلى بعضها البعض ، و تجمع نفسها إلى أنابيب طويلة متنامية ومتجمعة ذاتياً تقوم بثقب الغشاء الخلوي ، وتعمل مجموعات الأنابيب المتجاورة هذه على فتح مسام أكبر في جدار الخلية البكتيرية ، وخلال دقائق معدودة تموت الخلية البكتيرية نتيجة لتشتيت الجهد الكهربائي الخارجي لغشائها، وهذا ما ينهي حياة الخلية عملياً.

وقد أظهرت هذه التقنية نجاحاً ملحوظاً في القضاء على كل من الجراثيم العنقودية الذهبية المعندة وعصيات القيح الأزرق وغيرها الكثير.

وعلى هذا نرى أن مبدأ النانوبيوتكس و النانوتيوب يختلف تماماً عن طريقة عمل المضادات الحيوية والمطهرات وبذلك يصعب على هذه الكائنات أن تطور مناعة ذاتية أو مقاومة . وهي طريقة مختلفة تماماً عن طريقة عمل المضادّات الحيوية والمطهرات الكيماوية، ويتوقع أن تبدأ مثل هذه التجارب على البشر بعد حوالي ٢- ٣ سنوات من الآن ونجاح هذه الطريقة يوفر وبحساب منظمة الصحة العالمية مبلغ عشرة بلايين دولار سنوياّ وهي تكلفة معالجة الإصابات الناجمة عن العدوى بالبكتريا المقاومة للمضادات الحيوية.

وأول استخدام طبي للتقنية النانو نية يثبت جدارته حالياً في التجارب، بعد أن نجحت (تيجال ديساي) من جامعة (إلينوي) الأمريكية في تطوير جهاز مهندس بالتقنية النانونية يزرع في الجسم، بحيث يغني الأشخاص المصابين بداء السكري عن استخدام حقن الأنسولين، وقد مضت عدة أسابيع على الفئران المصابة بالسكري ولديها هذا الجهاز مزروعاً في أجسادها من دون أن تحتاج إلى حقن الأنسولين، أو تبدي أي مظاهر تدل على رفض الجهاز المزروع.

وتَعد تطورات كهذه بتغيير طريقة تناولنا للدواء، وتوشك الأجهزة الذكية التي تزرع في الجسم لإعطاء الأدوية بدقة لدى الحاجة إليها، أن تنزل إلى الأسواق، وفي الطريق حاليا أجهزة إلكترونية تأمر الخلايا بإفراز هرمونات محدودة عندما يحتاجها جسم الإنسان، ومولدات للكهرباء ومحركات تجمع نفسها داخل الخلية، وتستغل مصادر الطاقة الخاصة بالخلية لاستعمالها.

تكنولوجية النانو وعلاج السرطان:

يمكن للأجهزة الدقيقة أن تعمل بشكل جذري على تغيير علاج السرطان إلى الأفضل وإن تزيد بشكل كبير من عدد العناصر العلاجية، وذلك لأن الوسائل الدقيقة، على سبيل المثال يمكن أن تعمل كأدوات مصممة حسب الطلب تهدف لتوصيل الدواء وقادرة على وضع كميات كبيرة من العناصر الكيميائية العلاجية أو الجينات العلاجية

داخل الخلايا السرطانية مع تجنب الخلايا السليمة وسوف يعمل ذلك بشكل كبير من تخفيض أو التخلص من المضاعفات الجانبية السلبية التي تصاحب معظم طرق العلاج الحالية للسرطان .

وهناك مثال جيد من العالم البيولوجي وهي كبسولة الفيروس، المصنعة من عدد محدد من البروتينات، كل منها له خصائص كيميائية محددة تعمل معا على إنشاء وسيلة متعددة الوظائف دقيقة لتوصيل المواد الجينية. سوف تعمل تكنولوجية التصغير على تغيير أساس تشخيص وعلاج والوقاية من السرطان، ومن خلال الوسائل الدقيقة المبتكرة القادرة على القيام بوظائف طبية بما في ذلك الكشف عن السرطان في مراحله المبكرة وتحديد موقعه في الجسم وتوصيل الأدوية المضادة للسرطان إلى الخلايا السرطانية .

قنابل نانونية لتفجير الخلايا السرطانية:

طور علماء من مركز السرطان (ميموريان كيتيرنج) الأمريكي قنابل مجهريه ذكية تخترق الخلايا السرطانية، وتفجرها من الداخل. استخدم العلماء بقيادة (ديفيد شينبيرج) التقنية النانونية في إنتاج مثل هذه القنابل ، ومن ثَم استخدامها في قتل الخلايا السرطانية في فئران المختبر. وعمل العلماء على تحرير ذرات مشعة من مادة (أكتينيوم ٢٢٥) ترتبط بنوع من الأجسام المضادة من (قفص جزيئي)، ونجحت هذه الذرات في اختراق الخلايا السرطانية ومن ثم في قتلها.

وأكد (شينبيرج) أن فريق العلماء توصل إلى طريقة فعالة لربط الذرات بالأجسام المضادة ومن ثَم إطلاقها ضد الخلايا السرطانية. واستطاعت الفئران المصابة بالسرطان أن تعيش ٣٠٠يوم بعد هذا العلاج، في حين لم تعِش الفئران التي لم تتلقَّ العلاج أكثر من ٤٣ يوماً.

وتوجد في كل (قنبلة) خلية ذات عناصر إشعاعية قادرة على إطلاق ثلاث جزيئات عند اضمحلالها. وكل جزئ من هذه الجزيئات تطلق ذرة ألفا (ذات الطاقة

العالية)، لذلك فإن وجودها داخل الخلية السرطانية يقلص من احتمال قيام ذرات ألفا بقتل الخلايا السليمة.

وتم تجريب الطريقة على خلايا مستنبَتة مخبريا من مختلف الأنواع السرطانية التي تصيب الإنسان، مثل الأورام السرطانية في الثدي والبروستاتة وسرطان الدم. وستجرَّب الطريقة أولا في مكافحة سرطان الدم بعد أن تأكد العلماء أن التجارب على الفئران سارت دون ظهور أعراض جانبية.

التطبيقات العسكرية:

يتنافس كل من الجيش الأمريكي ووكالة ناسا على العمل ضمن هذا المجال فيأملون في الحصول على الملابس التي يمكن تصغير نفسها حتى تكون بمقاس مرتديها ، أو يمكنها أن تتصلب عند الخطر لتصبح مقاومة للرصاص واللهب ، أو تغير من لونها للتمويه أوالتخفي.

المجتمع والبيئة:

الطاقة الجديدة والمتجددة سوف تصبح عادية كمثال خلايا الطاقة المصنعة بناءا على علم الكم (Quantum dots) يمكن أن تصبح أكثر من ٨٥% كفاءة الرياح ، الامواج ، وطاقة الحرارة الكونية (Geothermal energy) سوف تستغل بطريقة أكثر كفاءة باستخدام مواد لتخزينها واستغلالها بطريقة متقدمة مثل بطاريات الهيدروجين وخلايا الوقود ، وقياس ذلك بواسطة حسابات خاصة ، سوف يمكننا من مراقبتها ومعرفة تأثيرها على البيئة واتخاذ اجراءات سريعة بدلا من سياسة الانتظار لنرى ما سوف يحدث.علم النانو سوف يمكننا من التخلص من التلوث الموجود أصلا في بيئتنا وسوف يساعدنا على الاستخدام الامثل لمواردنا .

تطبيقات أخرى :

وما يعكف عليه العلم الآن أن يغير طريقة الترتيب بناء على النانو، من مادة إلى أخرى، وبحل هذا اللغز فإن ما كان يحلم به العلماء قبل قرون بتحويل المعادن الرخيصة إلى ذهب سيكون ممكنا، لكن الواقع أن الذهب سيفقد قيمته.

وتعتبر طرق التصنيع اليوم غير متقنة على مستوى الجزيئات. فالصب والطحن وحتى الطباعة على الحجر تقوم بنقل الذرات في مجموعات ضخمة ، وفي المستقبل، سوف تسمح لنا تكنولوجية التصغير ان تقوم بترتيب مكونات البناء الجوهرية للطبيعة بسهولة وبدون تكلفة وفي معظم الأحيان حسبما تسمح به قوانين الطبيعة. كما تسمح بتصنيع جيل جديد تماما من المنتجات الأقوى والأخف وزنا بل والأكثر دقة. ومن الجدير بالذكر أن كلمة (تكنولوجية التصغير) أو (نانو تكنولوجي) أصبحت شائعة إلى حد كبير ويتم استخدامها لوصف العديد من أنواع الأبحاث حيث تكون أبعاد المادة المصنعة اقل من 1.000 نانومتر.

كما يمكننا استخدام تكنولوجية تصنيع جيدة تسمح لنا ببناء أنظمة كمبيوتر بشكل غير مكلف بواسطة كميات من العناصر المنطقية التي تكون جزيئية في كل من الحجم والدقة، ومرتبطة ببعضها البعض من خلال أنماط معقدة وبالغة الحساسية. وسوف تسمح تكنولوجية التصغير بالقيام بذلك .ويمكننا استخدام مصطلح (تكنولوجية التصغير الجزيئية) أو (التصنيع الجزيئي) بدلا عن (النانو تكنولوجي) ولكن ايا كان المصطلح الذي نقوم باستخدامه، فإنه يتعين عليه أن يسمح لنا بان نقوم بشكل جوهري بوضع كل ذرة في المكان الصحيح، وان نجعل كل هيكل متناسق مع قوانين الطبيعة التي يمكن أن نحددها بالتفاصيل الجزيئية، مع عدم تجاوز تكاليف التصنيع بشكل بالغ لتكلفة المواد الخام والطاقة المطلوبة.

وينجم عن شرط التكلفة المنخفضة اهتمام بأنظمة تصنيع النسخ المتطابقة ذاتياً، حيث يمكن لهذه النظم القيام بعمل نسخ عن نفسها وتصنيع منتجات مفيدة. فإذا أمكننا تصميم وبناء هذا النظام، فإن تكلفة تصنيع هذا النظام وتكاليف تصنيع الأنظمة المشابهة

والمنتجات التي تعمل على إنتاجها (بافتراض قدرتها على إنتاج نسخ عن نفسها في بيئة غير مكلفة بشكل معقول) سوف تكون منخفضة للغاية.

انجازات في علم النانوتكنولوجي

١.أصغر إعلان في العالم:

في عام ١٩٩٠تمكن الباحثون في مختبر فرعي لإحدى شركات الإلكترونات العالمية العملاقة من صنع أصغر إعلان في العالم، حيث استخدموا ٣٥ ذرة من عنصر الزينون في كتابة اسم الشركة ذي الحروف الثلاثة على واجهة مقر فرعها بالعاصمة السويسرية! ويتنبأ العلماء بمستقبل واعد لهذه التقنية، التي باتت الدول الصناعية في أوروبا واليابان والولايات المتحدة تضخ إليها ملايين الدولارات من أجل تطويرها.

والولايات المتحدة وحدها التزمت هذا العام بتخصيص أكثر من ٤٩٧ مليون دولار للتقنية النانوية واستخداماتها، كما أن شركات الكمبيوتر الكبرى المهتمة بالبحث العلمي، مثل (HP) و(IBM) تقوم بتخصيص ما يصل إلى ثلث المبالغ المخصصة للبحوث العلمية على التقنية النانوية.

وقد ظهرت عدة تقارير علمية دفعة واحدة، واحتلت أبحاث النانوتكنولوجي باباً كاملاً في مجلة العلم الأمريكية (ساينس)في نوفمبر (٢٠٠٠م)، ثم تلاها عدة تقاريرفي مطبوعات علمية أخرى كمجلة الطبيعة في مطبوعات علمية أخرى كمجلة الطبيعة (Nature)

٢.**البلاستيك المهجن**:

الباحثون في علم المواد يستخدمون هذه التقنيةلتغيير خو اص البلاستيك والزيوت والأنسجة لتصبح مقاومة للحرارة وزيادة قوتها ومرونتها.

وتقوم حالياً شركة (هايبرد بلاستيك)، أو البلاستيك المهجن، بإضافة مواد مصنعة عن طريق التقنية النانو ية لمواد تمتد من زيوت المحركات النفاثة وحتى ألواح

الدوائر الكهربائية في القوارب وأحواض السباحة .وتعتبر هذه الجسيمات الدقيقة التي تبيعها الشركة صغيرة جداً لدرجة أن قطر أكبر جسيم يقدر بحوالي ٣ نانومتر،(أي واحد من مليار من المتر) .

وتُكسب هذه الجسيمات البلاستيك خواص فريدة كالقدرة على مقاومة الحرارة واللهب والبرد، فضلا عن زيادة صلابته.

ومن شركات الكيماويات الأخرى التي تدرس مجال التقنية النانوية شركة(دوبونت) التي يحاول علماؤها صناعة ألياف توصل الكهرباء ويمكنها تغيير شكلها من المستدير إلى المثلث والمربع. وتهدف (دوبونت) لاستخدام هذه الألياف في الثياب التي تغير لونها وحجمها وفقا لطلب المرتدي .

كما تقوم شركة (نانوفيز تكنولوجيز) ببيع جسيمات دقيقة مثل أكسيد الزنك مصنعة عن طريق استخدام التقنية النانو ية لصانعي شتى المنتجات من التغليف الصناعي إلى مستحضرات التجميل .

وتختبر (ناسا) أنواعاً جديدة من البلاستيك الذي يحتوي على هذه الجسيمات على هيكل محطة الفضاء الدولية، وتختبره أيضا القوات العسكرية وشركات الطيران لاستخدامه كبديل للهياكل المعدنية على الطائرات والصواريخ والأقمار الصناعية .يعتبر صنع هياكل الصواريخ من البلاستيك المحتوي على هذه الجسيمات أرخص وأسهل من الهياكل المعدنية التي يمكنها حماية الحمل سواء كان ذخيرة أو قمراً صناعياً من الاصطدام مع النفايات التي تطوف بالفضاء وتتحمل برد الفضاء القاسي وحرارة الاحتكاك عند العودة للأرض .

وتصنع نفس الشركة الآنفة الذكر زيتاً لسلاح الجو الأمريكي يمكنه تحمل حرارة تصل إلى ٥٠٠ درجة فهرنهايت، أي حوالي ١٠٠درجة أعلى من الزيوت الحالية من دون الاحتراق أو الانحلال.

وتقوم شركة (ترايتون) بتطوير تغليف بلاستيكي مقاوم للخدش لخوذات الطيارين في البحرية الأمريكية. وقد يُستخدم هذا التغليف بعدسات النظارات العادية قريبا .

أضرار النانو تكنولوجي

ذكرت جريدة اليوم في إحدى أعدادها المقال التالي:

"بدأت الحكومة البريطانية البحث في الفوائد والأخطار المحتملة النانوتكنولوجي من خلال دراسة تجريها الجمعية الملكية والأكاديمية الملكية للهندسة. وبينما يستطيع علم الوراثة تغيير الحامض النووي "دي.إن.إيه" فإن النانوتكنولوجي في مقدوره التلاعب بالمادة بكافة صورها حيةكانت أم ميتة وإعادة ترتيب جزيئاتها، ومن بين الفوائد المرجوة لهذا العلم تصنيع مواد جديدة أكثر ذكاء يمكن استخدامها في صنع الطائرات والمركبات والمباني والارتقاء بسبل علاج الأمراض وصنع أجهزة الكومبيوتر فائقة السرعة.

لكن المعارضين، وخصوصا أمير تشارلز أمير ويلز، يخشون أن تؤدي النانوتكنولوجي إلى تطوير أسلحة دمار شامل خطيرة أو إنسان آلي لديه القدرة على استنساخ نفسه. بل وادعى البعض أن هذه التكنولوجيا ربما تؤدي إلى تصنيع كائنات شديدة الدقة لديها القدرة على استنساخ نفسها تخرج عن نطاق السيطرة البشرية وتدمر العالم وتحيله إلى مادة لزجة.

لكن ألياف الأنبوب الكربوني شديد الصغر التي جرى تصنيعها في جامعة تكساس في دالاس ريتشاردسون بالولايات المتحدة تكاد تنعدم أضرارها. وبالاضافة إلى خواصها الكهربية فإنها تتمتع بقوة لا تصدق إذ تتجاوز قوتها قوة السلك الصلب بمقدار عشرين مر ة وتضارع الخيوط الحريرية التي تنسجها العنكبوت.

وقال فريق من العلماء بقيادة راي بوجمان في مجلة نيتشر استخدمنا ألياف الأنبوب الكربوني شديد الصغر لعمل مكثفات فائقة القدرة وأدخلناها في الأنسجة .وتشمل التطبيقات الالكترو - نسيجية الواعدة لهذه الألياف التي يسهل نسجها وحياكتها أجهزة الاستشعار والوصلات الإلكترونية والدروع الكهرومغناطيسية والهوائيات والبطاريات".

ما قيل عن النانوتكنولوجي

روب كامبوس :

تدور حبكات العديد من أفلام هوليود حول آلات أصغر حجماً من الخلية، تتغلغل عبر الفضاء الداخلي للجسم البشري وتتصدى للميكروبات والفيروسات التي تهاجمه، وبصورة من الصور تشبه فانتازيا المستقبل.وإذا كانت هذه الصورة هوليودية على الشاشة الفضية، إلا أن الباحثين في معامل التكنولوجيا العملية قد خطوا خطوات جبارة في مجال النانو- تكنولوجيا التي تنتج آلات متناهية الصغر (نانوية) هي ما يسمى بالنانو-تكنولوجيا التي تستند إلى علوم تمكننا من تصنيع أشياء على مستوى الذرات تقوم بمحاربة الأمراض من خلية إلى أخرى.

وتُقاس الخلايا بالميكرونات، ويساوي الميكرون الواحد مليون جزء من المتر، وتقاس الذرات بالنانومتر الذي يعادل الواحد منه مليار جزء من المتر أو واحدا على ٨٠ ألف جزء من عرض شعرة الإنسان. وترمي النانو-تكنولوجيا إلى بناء وتسخير أشياء على المستوى الذري (من حيث الحجم).

د.جاك جودي أستاذ الهندسة **الكهربائية بجامعة كاليفورنيا،لوس أنجلوس**:

هناك تصوران لنمو النانوتكنولوجي؛ أولاهما ما يسميه بتكنولوجيا استقطار الثمالة، حيث يسعى مهندسو الجزيئات إلى تشكيل بنيات من النانو -تكنولوجيا تم إنتاجها الواحدة بعد الأخرى من وحدات جزيئية. أما التصور الثاني فيقوم على تصغير التكنولوجيات الموجودة إلى الحد الأقصى. وقد نشأ النوع الأخير من علوم وتطبيقات الإلكترونيات الدقيقة، وتعرف مخترعاته باسم الميمات (MEMS).

يقول جودي" :ظلت تكنولوجيا التصنيع المستخدمة في صنع الميمات تتطور باستمرار بفضل صناعة الدوائر الكهربية المتناهية الصغر. ولقد أصبح من الممكن الآن إنتاج بنيات كهربية أو ميكانيكية أو سائلة تتميز بدقة الحجم بصورة تكاد تكون متناهية، إذ ننتج من الزجاج أو السيلكون وحدات ومعدات أصغر حجما من الميكرون". وهذا يعني أن الآلات المعقدة يجرى استبدالها بأخرى أصغر فأصغر حجما.

في الوقت الحاضر يعمل الدكتور جوديفي مجال ٍ من التكنولوجيا لعزل الخلايا ومراقبة وظائفها الفسيولوجية، ويقول عن مشروعه: "إن تعريض الخلية لمؤثرات الإشعاع أو درجة الحرارة أو معدلات تدفق السوائل أو الكيماويات الأخرى سيغيّر البيئة الخلوية الخارجية. وحاليا يتم كل ذلك ولكن بوتائر بطيئة جدا. إلا أن التكنولوجيا التي نعكف على تطويرها تسمح باستخدام عدد كبير من الخلايا في وقت واحد، وهذا بدوره يسمح للعلماء بدراسة سلوكيات الخلية بدقة أكبر مما كان متوفرا في الماضي. فقد كانوا آنذاك يستطيعون مراقبة ما يحدث خارج الخلية دون أن تكون لديهم أية فكرة عما يحدث بداخلها.الأداة المفضلة لدى جودي هي الرقاقة البيولوجية وهي قطعة صغيرة مربّعة من الزجاج مساحتها سنتيمتر في سنتيمتر، وبها قنوات صغيرة تستطيع أن تعزل الخليّة والمنافذ المتصلة بالخليّة .ويستطيع العالم أن يراقب ما يحدث للخلية عن طريق المجهر. ويخبرنا جودي أن شركات تصنيع الأدوية تبدي اهتماما كبيرا بهذه التكنولوجيا التي يعمل على تطويرها لأنها ستسمح لتلك الشركات بتطوير مكتشفاتها في علم وصناعة الدواء.

توماس ويبستر(المهندس البيولوجي والأستاذ المساعد في جامعة بردو) :

إن إيصال الدواء إلى الجسم هو واحد من أول تطبيقات النانو -تكنولوجيا المرشحة للاستخدام. وعن طريقها يمكن أن ندخل إلى الخلية جرعة دوائية يقل حجمها عن ١٠٠ نانو متر دون أن تلفت النظر". والواقع أنه يمكن إعطاء الأدوية للمرضى على هيئة أقراص يقاس حجمها بالميكرون تقوم بإطلاق الدواء على الخلايا المستهدفة. والنظرية المعتمدة هنا هي أن فاعلية الدواء تزداد إذا كانت كمياته متناهية الصغر بهذا الشكل. وكلما تضاءلت الجرعة الدوائية كلما قل ضررها على المريض لأنها لن تستهدف حينها إلا الخلايا المسببة للمرض أو للعدوى.

ويبحثويبستر أيضا في وسائل استخدام المواد النانوية لترميم وإصلاح الأنسجة الطبيعية، إذ برهنت الوسائل التقليدية مثل زرع العظام والأوعية الدموية على عجزها عن توفير النعومة واستواء السطح الذي يتوافر باستخدام المواد النانوية. ويقول وبستر: "لقد

وجدنا أن البيئات النانوية تساعد الجسم على إعادة إنتاج نفسه بصورة أفضل سواء في مجال العظام أو الأوعية الدموية أو الغضروفيات وخلايا المثانة. ولقد جرى إثبات كل ذلك عمليا. ومن المتوقع أن تتوسع استخداماتها في الجسم البشري في وقت قريب نسبيا ."كما أنه من المتوقع أن تبقى المواد الجديدة عاملة داخل الجسم لمدة أطول من مدة الـ١٥ عاما المتاحة حاليا لمعظم أشكال استزراع الأعضاء التقليدية.

جنيفر ويست - الأستاذة المساعدة **لقسم الهندسة البيولوجية بجامعة رايس بمدينة هيوستن بولاية تكساس والمختصة بأبحاث علاج السرطان وإطالة عمر المصابين به:**

وتجري أبحاثها على مادة تعرف باسم القشور النانوية تتميز بقدرتها على التشبّع بالضوء من الدرجة فوق الأشعة الحمراء، والمعروف بقدرته على التغلغل في الجسم إلى أعماق كبيرة. وتشرح جنيفر العملية قائلة: "نقوم بحقن القشور النانوية بشكل منتظم ونتركها تتحرك خلال الجسم لتصل إلى الخلايا السرطانية وتلتحم بها، ثم نقوم بتسليط أشعة قريبة من الأشعة فوق الحمراء عبر الأنسجة، وبسبب ذلك ترتفع حرارة القشور النانوية. وتخلق فتحات مسامية في غشاء الخلايا السرطانية فتلتحم بها وتسبب موتها."

وتضيف جنيفر ويست: "إن ذلك تطبيق مدهش للنانو - تكنولوجيا. وقد رأينا حالات شفاء كامل من الأورام في الفئران والحيوانات المعملية الأخرى التي كنا نجري تجاربنا عليها، ومنها ما عاش لشهور وشهور دون أن تعود الأعراض التي كان يعاني منها إلى الظهور."

ملخص

علم النانو هو علم الجزيئات المتناهية في الصغر ، ويتميز بأن المواد في حجم النانو تكتسب خواص جديدة تختلف تماما عن مماثلاتها في الأحجام الأكبر .

ويمكن استخدام هذه التقنية في مجالات كثيرة اعتمادا على المبدأ السابق ، فيمكن استخدامها في الطب في مجالات كثيرة منها استخدامها بديلا للمضادات الحيوية و في علاج السرطان وفي امكانية توصيل الدواء للمكان المخصص ليقوم بتأثيره .

كما يمكن استخدامها في الصناعة حيث تكسب المواد الصلابة والمحافظة على هيئتها من مؤثرات البيئة . وتستخدم أيضا في صناعة الاغذية كمواد حافظة ومكونات للأواني التي تحويها .

أما عن استخدامها في صناعة الأسلحة فهذا أكثر ما يقلق بعض الدول . والجدير بالذكر أن جزيئات النانو كانت تستخدم من قديم الزمان في صناعة السيوف والتي تكون الاكثر حدة في هذه الصورة .

ولا ننكر استخدامها المتوقع في صناعة الحواسيب الإلكترونية وانها ستضفي على هذه الصناعة الكثير من الدقة والاتقان . ولكن لكل سيف حدان أما عن الحد الثاني للسيف أن هذه الجزيئات ربما تؤدي الى بعض المضاعفات لجسم الإنسان الضارة نظرا لصغر حجمها مما يؤدي الى سرعة امتصاصها و وصولها للمخ . وهناك بعض الدراسات تشير الى وجود بعض التأثيرات على البيئة ولكنها تكاد تكون لا تذكر .

الخاتمة

هذا ما استطعنا تقديمه من خلال بحثنا هذا الذي لم نطل عليكم فيه حتى لا يدخل إلى أنفسكم الملل ولكننا اختصرنا فيه وذكرنا منه المفيد و نأمل من المولى عز وجل أن يوفقنا فيه وتعم الفائدة منه ، وبإذن الله ينال البحث المتواضع هذا رضاكم واستحسانكم.

المراجع

١. عن مقال للدكتورة رحاب الصوّاف(**ماجستير في التشخيص المخبري**) –(**دكتوراه في الكيمياء الحيوية من جامعة دمشق**)

٢. **جريدة الجزيرة**

٣. **http://www.nano.org.uk**

I. Executive Summary

Believing that Nanotechnology (NT) will change the world in the next 10-20 years as it will participate in changing all the recent concepts of different nowadays applications including Industry, Agriculture, Water Purification, Medicinal Diagnosis and Treatment, even Military applications leading to a massive scientific revolution in nearly all sciences.

The revolution caused by NT depends on the fact that nano-sized particles have much great difference properties than the same ordinary-sized particles, leading to discovering new properties for the now-known substances so that these substances could have better properties or could be used for new purposes.

Many countries nowadays are doing research on NT, how to develop it, manufacturing new machines that will serve NT. Among them are the U.S.A, the European Union and Kingdom of Saudi Arabia as an example in the Middle East.

Also many institutes are established to aid reaching the NT goals as National Nanotechnology Standardization Laboratory (NSL), National Nanotechnology Initiative (NNI) and others.

Looking up for a general definition of NT we will define it as: "The production and use of materials with purposely engineered features close to the atomic or molecular scale".

In this Research, we will try to focus on some important concepts of NT, define devices and methods used and give some examples on various applications that all already applied or may be applied in a few years.

Among the material introduced will be Nano-scale significance, what nanomaterials are, how they are constructed and what their properties are, including some examples on materials designed using Nano-scale.

Then, various NT applications will be reviewed, starting by Nano-Medicine, how will NT change today's methods of diagnosis and treatment and how will it overcome the short comings of these methods. It will be showed that NT will not only be able to treat some diseases and fix broken tissues, but it will be able to enter the cells themselves and control their activity. Thus, treating more complicated disorders. Also it will avoid the appearance of any new plague due to new unknown micro-organisms due to its better ability to identify, diagnose and treat diseases.
The Nano-medicine will also include some future applications that will make the physicians work easier. So, NT ensures a better human's health for the next upcoming years.

An Important part of NT is its Cancer diagnosis and therapy which will be discussed including the devices used and mechanisms of their action.

Another important application will be the use of NT in food processing, preservation and agriculture including today's already present nanofoods and other materials, how the shelf life of packaged food will be extended and some applications on NT used in agriculture. And a final example, how Water can be purified using NT.

Finally, limitations of NT must be considered as a new technology so as to try to get the best of NT without introducing risks mainly to the human being.

NT will provide a better, more advanced and healthier life for the human being. By other meaning, it will present us a new future in all fields.

"Nanotechnology is a truth and promises it holds are stronger than fiction"

II. Introduction

In 1965, Gordon Moore, one of the founders of Intel Corporation, made the astounding prediction that the number of transistors that could be fit in a given area would double every 18 months for the next ten years. This it did and the phenomenon became known as "Moore's Law".
This trend has continued far past the predicted 10 years until this day, going from just over 2000 transistors in the original 4004 processors of 1971 to over 700,000,000 transistors in the Core 2. There has been a corresponding decrease in the size of individual electronic elements, going from millimeters in the 60's to hundreds of nanometers in modern circuitry.

At the same time, the chemistry, biochemistry and molecular genetics communities have been moving in the other direction. Over much the same period, it has become possible to direct the synthesis, either in the test tube or in modified living organisms.

Finally, the last quarter of a century has seen tremendous advances in our ability to control and manipulate light. We can generate light pulses as short as a few femtoseconds (1 fs = 10^{-15} s). Light too has a size and this size is also on the hundred nanometer scale.

II.1. Historical background

Humans have unwittingly employed nanotechnology for thousands of years.

For example: in making steel, paintings and in vulcanizing rubber. Each of these processes rely on the properties of stochastically-formed atomic ensembles mere nanometers in size, and are distinguished from chemistry in that they don't rely on the properties of individual molecules. But the development of the body of concepts now subsumed under the term nanotechnology has been slower.

The first mention of some of the distinguishing concepts in nanotechnology (but predating use of that name) was in 1867 by James Clerk Maxwell when he proposed as a thought experiment a tiny entity known as Maxwell's Demon able to handle individual molecules.
The first observations and size measurements of nano-particles was made during first decade of 20th century. They are mostly associated with Richard Adolf Zsigmondy who made detail study of gold sols and other nanomaterials with sizes down to 10 nm and less. He published a book in 1914.

He used ultra microscope that employs dark field method for seeing particles with sizes much less than light wavelength. Zsigmondy was also the first who used nanometer explicitly for characterizing particle size. He determined it as 1/1,000,000 of millimeter. He developed a first system classification based on particle size in nanometer range.

II.2. What is Nanotechnology?

One of the problems facing nanotechnology is the confusion about its definition. Most definitions revolve around the study and control of phenomena and materials at length scales below 100 nm and quite often they make a comparison with a human hair, which is about 80,000 nm wide.

Some definitions include a reference to molecular systems and devices and nanotechnology "purists" argue that any definition of nanotechnology needs to include a reference to "functional systems". The inaugural issue of Nature Nanotechnology asked 13 researchers from different areas what nanotechnology means to them and the responses, from enthusiastic to skeptical, reflect a variety of perspectives.

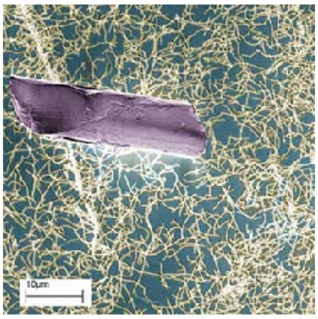

Figure (1):Human hair fragment and a network of single-walled carbon nanotubes

It seems that a size limitation of nanotechnology to the 1-100 nm range, the area where size-dependant quantum effects come to bear, would exclude numerous materials and devices, especially in the pharmaceutical area, and some experts caution against a rigid definition based on a sub-100 nm size.

Another important criteria for the definition is the requirement that the nano-structure is man-made. Otherwise you would have to include every naturally formed biomolecule and material particle, in effect redefining much of chemistry and molecular biology as "nanotechnology".

The most important requirement for the nanotechnology definition is that the nano-structure has special properties that are exclusively due to its nanoscale proportions.

II.3. Nanotechnology Definitions:

The U.S. National Nanotechnology Initiative (NNI) defines NT as: "The understanding and control of matter at dimensions of roughly 1 to 100 nanometers"…nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

The Europeans end to define it more simply as: "The dealing with applications and products with engineered structures smaller than 100 nanometers".

Generally, Nanotechnology (NT) is the production and use of materials with purposely engineered features close to the atomic or molecular scale. NT deals with putting things together atom-by-atom and with structures so small they are invisible to the naked eye. It provides the ability to create materials, devices and systems with fundamentally new functions and properties.

II.4. The Significance of Nanoscale

A nanometer (nm) is one thousand millionth of a meter. For comparison, a red blood cell is approximately 7,000 nm wide and a water molecule is almost 0.3nm across. People are interested in the nanoscale because it is at this scale that the properties of materials can be very different from those at a larger scale.

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

Chemists have been making polymers, which are large molecules made up of nanoscale subunits, for many decades and nanotechnologies have been used to create the tiny features on computer chips for the past 20 years. However, advances in the tools that now allow atoms and molecules to be examined and probed with great precision have enabled the expansion and development of nanoscience and nanotechnologies.

The bulk properties of materials often change dramatically with nano ingredients. Composites made from particles of nano-size ceramics or metals smaller than 100 nanometers can suddenly become much stronger than predicted by existing materials-science models. For example, metals with a so-called grain size of around 10 nanometers are as much as seven times harder and tougher than their ordinary counterparts with grain sizes in the hundreds of nanometers. The causes of these drastic changes stem from the weird world of quantum physics.

The bulk properties of any material are merely the average of all the quantum forces affecting all the atoms. As you make things smaller and smaller, you eventually reach a point where the averaging no longer works.

II.5. Reasons for the Difference in Material Properties by Applying Nanoscale:

1. Surface area:

Nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties.

2. Quantum effects:

They can begin to dominate the behaviour of matter at the nanoscale - particularly at the lower end - affecting the optical, electrical and magnetic behaviour of materials.

Examples of the effects these factors opaque substances become transparent (copper); stable materials turn combustible (aluminum); solids turn into liquids at room temperature (gold); insulators become conductors (silicon). A material such as gold, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscales.

Much of the fascination with nanotechnology stems from these quantum and surface phenomena that matter exhibits at the nanoscale.

This effect does not come into play by going from macro to micro dimensions.

II.6. Nanomaterials

Are those which have structured components with at least one dimension less than 100nm.

Nanomaterials can be constructed by 'top down' techniques, producing very small structures from larger pieces of material.
For example: by Etching to create circuits on the surface of a silicon microchip. They may also be constructed by 'bottom up' techniques, atom by atom or molecule by molecule.

II.6.1. Methods of Nanomaterials Construction:

1. Self-assembly:

In which the atoms or molecules arrange themselves into a structure due to their natural properties. Crystals grown for the semiconductor industry provide an example of self assembly, as does chemical synthesis of large molecules.

2. Using tools to move each atom or molecule individually.

Although this 'positional assembly' offers greater control over construction, it is currently very laborious and not suitable for industrial applications.

It has been 25 years since the scanning tunneling microscope (STM) was invented, followed four years later by the atomic force microscope, and that's when nanoscience and nanotechnology really started to take off. Various forms of scanning probe microscopes based on these discoveries are essential for many areas of today's research.

Current applications of nanoscale materials include very thin coatings used, for example, in electronics and active surfaces as self-cleaning windows.

II.6.2. Properties of Nanomaterials

In tandem with surface-area effects, quantum effects can begin to dominate the properties of matter as size is reduced to the nanoscale.

These can affect the optical, electrical and magnetic behaviour of materials, particularly as the structure or particle size approaches the smaller end of the nanoscale. Materials that exploit these effects include quantum dots, and quantum well lasers for optoelectronics.

For other materials such as crystalline solids, as the size of their structural components decreases, there is much greater interface area within the material; this can greatly affect both mechanical and electrical properties.

For example, most metals are made up of small crystalline grains; the boundaries between the grain slow down or arrest the propagation of defects when the material is stressed, thus giving it strength. If these grains can be made very small, or even nanoscale in size, the interface area within the material greatly increases, which enhances its strength.

For example, nanocrystalline nickel is as strong as hardened steel.

Understanding surfaces and interfaces is a key challenge for those working on nanomaterials, and one where new imaging and analysis instruments are vital.

III.6.3. Nanomaterial Science

Below we outline some examples of nanomaterials and the range of nanoscience that is aimed at understanding their properties. As will be seen, the behaviour of some nanomaterials is well understood, whereas others present greater challenges.

III.6.3.1. Materials can be produced that are nanoscale in:

-One dimension as very thin surface coatings.
-Two dimensions as nanowires and nanotubes.
-Three dimensions as nanoparticles.

III.6.3.1.1. Nanoscale in One Dimension

III.6.3.1.1.1. Thin films

They are used in the silicon integrated-circuit industry as many devices rely on thin films for their operation, and control of film thicknesses approaching the atomic level is routine.

Monolayers (layers that are one atom or molecule deep) are also routinely made and used in chemistry. The formation and properties of these layers are reasonably well understood from the atomic level upwards, even in quite complex layers (such as lubricants). Advances are being made in the control of the composition and smoothness of surfaces, and the growth of films.

III.6.3.1.1.2. Engineered surfaces

The ones that have tailored properties such as large surface area or specific reactivity are used routinely in a range of applications such as in fuel cells and catalysts. The large surface area provided by nanoparticles, together with their ability to self assemble on a support surface, could be of use in all of these applications.

III.6.3.1.2. Nanoscale in Two Dimensions

III.6.3.1.2.1. Carbon Nanotubes:

Carbon nanotubes (CNTs) were first observed by **Sumio Iijima** in 1991. CNTs are extended tubes of rolled rapheme sheets.

There are two types of CNT:

1-Single-walled (one tube)
2-Multi-walled (several concentric tubes)

Both of these are typically a few raphemes in diameter and several micrometers to centimeters long. CNTs have assumed an important role in the context of nanomaterials, because of their novel chemical and physical properties. They are mechanically very strong (their Young's modulus is over 1 terapascal, making CNTs as stiff as diamond), flexible (about their axis), and can conduct electricity extremely well (the helicity of the rapheme sheet determines whether the CNT is a semiconductor or metallic). All of these remarkable properties give CNTs a range of potential applications.

For example, in reinforced composites, sensors, nanoelectronics and display devices

CNTs are now available commercially in limited quantities. They can be grown by several techniques. However, the selective and uniform production of CNTs with specific dimensions and physical properties is yet to be achieved. The potential similarity in size and shape between CNTs and asbestos fibres has led to concerns about their safety.

II.6.3.1.2.2. Inorganic Nanotubes:

Inorganic nanotubes and inorganic fullerene-like materials based on layered compounds such as molybdenum disulphide were discovered shortly after CNTs. They have excellent tribological (lubricating) properties, resistance to shockwave impact, catalytic reactivity, and high capacity for hydrogen and lithium storage, which suggest a range of promising applications. Oxide-based nanotubes (such as titanium dioxide) are being explored for their applications in catalysis, photo-catalysis and energy storage.

II.6.3.1.2.3. Nanowires:

Nanowires are ultra fine wires or linear arrays of dots, formed by self-assembly. They can be made from a wide range of materials. Semiconductor nanowires made of silicon, gallium nitride and indium phosphides have demonstrated remarkable optical, electronic and magnetic characteristics (for example, silica nanowires can bend light around very tight corners).

Nanowires have potential applications in high-density data storage; either as magnetic read heads or as patterned storage media, and electronic and opto-electronic nanodevices, for metallic interconnects of quantum devices and nanodevices. The preparation of these nanowires relies on sophisticated growth techniques, which include self assembly processes, where atoms arrange themselves naturally on stepped surfaces, chemical vapour deposition (CVD) onto patterned substrates, electroplating or molecular beam epitaxy (MBE). The ‘molecular beams’ are typically from thermally evaporated elemental sources.

II.6.3.1.2.4. Biopolymers:

The variability and site recognition of biopolymers, such as DNA molecules, offer a wide range of opportunities for the self-organization of wire nanostructures into much more complex patterns. The DNA backbones may then, for example, be coated in metal. They also offer opportunities to link nano- and biotechnology in, for example, biocompatible sensors and small, simple motors.

Such self-assembly of organic backbone nanostructures is often controlled by weak interactions, such as hydrogen bonds, hydrophobic, or van der Waals interactions (generally in aqueous environments) and hence requires quite different synthesis strategies to CNTs, for example. The combination of one-dimensional nanostructures consisting of biopolymers and inorganic compounds opens up a number of scientific and technological opportunities.

II.6.3.1.3. Nanoscale in Three Dimensions

II.6.3.1.3.1. Nanoparticles:

II.6.3.1.3.1.1.About Nanoparticles

Nanoparticles are often defined as particles of less than 100nm in diameter that exhibit new or enhanced size-dependent properties compared with larger particles of the same material.

Nanoparticles exist widely in the natural world: for example as the products of photochemical and volcanic activity, and created by plants and algae. They have also been created for thousands of years as products of combustion and food cooking, and more recently from vehicle exhausts. Deliberately manufactured nanoparticles, such as metal oxides, are by comparison in the minority.

Nanoparticles are of interest because of the new properties (such as chemical reactivity and optical behaviour) that they exhibit compared with larger particles of the same materials. For example, titanium dioxide and zinc oxide become transparent at the nanoscale, however are able to absorb and reflect UV light, and have found application in sunscreens.

II.6.3.1.3.2. Applications of Nanoparticles:

1. In short-term:

   New cosmetics, textiles and paints.

2. In longer term:

   In methods of targeted drug delivery where they could be to used deliver drugs to a specific site in the body.

Nanoparticles can also be arranged into layers on surfaces, providing a large surface area and hence enhanced activity, relevant to a range of potential applications such as catalysts.

Manufactured nanoparticles are typically not products in their own right, but generally serve as raw materials, ingredients or additives in existing products. Nanoparticles are currently in a small number of consumer products such as cosmetics and their enhanced or novel properties may have implications for their toxicity.

II.6.3.1.3.2. Fullerenes:

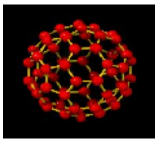

Figure (2): Model C60

In the mid-1980s a new class of carbon material was discovered called carbon 60 (C60).Harry Kroto and Richard Smalley, the experimental chemists who discovered C60 named it "buckminsterfullerene", in recognition of the architect Buckminster Fuller, who was well-known for building geodesic domes, and the term fullerenes was then given to any closed carbon cage.

C60 are spherical molecules about 1nm in diameter, comprising 60 carbon atoms arranged as 20 hexagons and 12 pentagons: the configuration of a football.

In 1990, a technique to produce larger quantities of C60 was developed by resistively heating graphite rods in a helium atmosphere. Several applications are envisaged for fullerenes, such as miniature ‘ball bearings’ to lubricate surfaces, drug delivery vehicles and in electronic circuits.

II.6.3.1.3.3. Dendrimers:

Dendrimers are spherical polymeric molecules, formed through a nanoscale hierarchical self-assembly process. They will be discussed later in details.

II.6.3.1.3.2. Quantum Dots:

Nanoparticles of semiconductors (quantum dots) were theorized in the 1970s and initially created in the early 1980s. If semiconductor particles are made small enough, quantum effects come into play, which limit the energies at which electrons and holes (the absence of an electron) can exist in the particles. As energy is related to wavelength (or colour), this means that the optical properties of the particle can be finely tuned depending on its size. Thus, particles can be made to emit or absorb specific wavelengths (colours) of light, merely by controlling their size.

Recently, quantum dots have found applications in composites, solar cells (Gratzel cells) and fluorescent biological labels
(for example to trace a biological molecule) which use both the small particle size and tuneable energy levels.

Recent advances in chemistry have resulted in the preparation of monolayer-protected, high-quality, monodispersed, crystalline quantum dots as small as 2nm in diameter, which can be conveniently treated and processed as a typical chemical reagent.

III. Applications of Nanotechnology
III.1. Nano Medicine

To understand what nanotechnology can do for medicine, we need a picture of the body from a molecular perspective. The human body can be seen as a work yard, construction site, and battleground for molecular machines. It works remarkably well, using systems so complex that medical science still doesn't understand many of them. Failures, though, are all too common.

III.3.1. Medicine Today

When the body's working, building, and battling goes awry, we turn to medicine for diagnosis and treatment. Today's methods, though, have obvious shortcomings.

III.3.2. Shortcomings of Today's Medicine

Current medicine is limited both by its understanding and by its tools. In many ways, it is still more an art than a science.
Better tools could provide both better knowledge and better ways to apply that knowledge for healing. Doctors today can't affect molecules in one cell while leaving identical molecules in a neighboring cell untouched because medicine today cannot apply surgical control to the molecular level.

III.1.3. Nanotechnology in Medicine

Developments in nanotechnology will result in improved medical sensors. As protein chemist Bill DeGrado notes, "Probably the first use you may see would be in diagnostics: being able to take a tiny amount of blood from somebody, just a pinprick, and diagnose for a hundred different things. Biological systems are already able to do that, and I think we should be able to design molecules or assemblies of molecules that mimic the biological system".

In the longer term, the story of nanotechnology in medicine will be the story of extending surgical control to the molecular level. The easiest applications will be aids to the immune system, which selectively attack invaders outside tissues. More difficult applications will require that medical nanomachines mimic white blood cells by entering tissues to interact with their cells. Further applications will involve the complexities of molecular-level surgery on individual cells. One approach to nanomedicine would make use of microscopic mobile devices built using molecular-manufacturing equipment.They would either be biodegradable, self-collecting, or collected by something else once they were done working. Development will start with the simpler applications.

III.1.4.Applying Nanomedicine outside the body:

The skin is the body's largest organ, and its exposed position subjects it to a lot of abuse. This exposed position, though, also makes it easier to treat. Among the earlier applications of molecular manufacturing may be those popular, quasimedical products, cosmetics. A cream packed with nanomachines could do a better and more selective job of cleaning than any product can today. It could remove the right amount of dead skin, remove excess oils, add missing oils, apply the right amounts of natural moisturizing compounds, and even achieve the elusive goal of "deep pore cleaning" by actually reaching down into pores and cleaning them out. The cream could be a smart material with smooth-on, peel-off convenience.

III.1.5. Applying Nanomedicine inside the body:

III.1.5.1.In the Bloodstream:

The bloodstream carries everything from nutrients to immune-system cells, with chemical signals and infectious organisms besides.

Figure (3): Immune Machines

Medical nanodevices could augment the immune system by finding and disabling unwanted bacteria and viruses. The immune device in the foreground has found a virus; the other has touched a red blood cell.

Here, it is useful to think in terms of medical nanomachines that resemble small submarines, like the ones in Figure (1). Each of these is large enough to carry a nanocomputer as powerful as a mid-1980s mainframe, along with a huge database (a billion bytes), a complete set of instruments for identifying biological surfaces, and tools for clobbering viruses, bacteria, and other invaders.

III.1.5.2.Inside tissues:

White blood cells can leave these vessels to move among the neighboring cells. Immune machines and similar devices could do the same. Fighting organisms in the bloodstream would be a major advance, cutting their numbers and inhibiting their spread. Roving medical nanomachines, though, will be able to hunt down invaders throughout the body and eliminate them entirely.

III.1.5.2.1. Eliminating Invaders:

Bacteria, protozoa, worms, and other parasites have even more obvious molecular markers. Once identified, they could be destroyed, ridding the body of the disease they cause. Immune machines thus could deal with tuberculosis, strep throat, leprosy, malaria, amoebic dysentery, sleeping sickness, river blindness, hookworm, flukes, candida, valley fever, antibiotic-resistant bacteria, and even athlete's foot.

III.1.5.2.2. Herding Cells and Rebuilding Tissues:

Cells respond to a host of signals from their environment (ex: chemicals). Cell-herding devices would use these signals to stimulate cell division where it is needed and to discourage it where it is not.

For example: they could restore artery walls and artery linings to health, by ensuring that the right cells and supporting structures are in the right places. This would prevent most heart attacks.

III.1.5.2.3. Working on Cells

Today, researchers can inject new DNA into cells using a tiny needle; small punctures in a cell membrane automatically reseal. But both these techniques use tools that on a cellular scale are large and clumsy—like doing surgery with an ax or a wrecking ball, instead of a scalpel. Nano-scale tools will enable medical procedures involving delicate surgery on individual cells.

III.1.5.2.4. Eliminating Viruses by Cell Surgery

When the immune system deals with a viral illness, it both attacks free virus particles before they enter cells, and attacks infected cells before they can churn out too many more virus particles.

These viruses can be eliminated by molecular-level cellular surgery. The required devices could be small enough to fit entirely within the cell.

III.1.5.2.5. Healing Body and Limb

The ability to herd cells and to perform molecular repairs and cell surgery will open new vistas for medicine. These abilities apply on a small scale, but their effects can be large scale.

III.1.5.2.6. Correcting Chemistry

In many diseases, the body as a whole suffers from misregulation of the signaling molecules that travel through its fluids.

For example: Obesity is a serious medical problem, increasing the risk of diabetes mellitus, osteoarthritis, degenerative diseases of the heart, arteries, and kidneys, and shortening life expectancy. And the supposed cause, simple overeating, has been shown to be incorrect—something dieters had always suspected, as they watched thinner colleagues gorge and yet gain no weight.

The ability to lay in stores of fat was a great benefit to people once upon a time, when food supplies were irregular, nomadism and marauding bands made food storage difficult and risky, and starvation was a common cause of death. Our bodies regulate fat reserves accordingly. This is why dieting often has perverse effects. The body, when starved, responds by attempting to build up greater reserves of fat at its next opportunity. The main effect of exercise in weight reduction isn't to burn up calories, but to signal the body to adapt itself for efficient mobility.

Obesity therefore seems to be a matter of chemical signals within the body, signals to store fat for famine or to become lean for motion. Nanomedicine will be able to regulate these signals in the bloodstream, and to adjust how individual cells respond to them in the body. The latter would even make possible the elusive "spot reduction program" to reshape the distribution of body fat.

III.1.5.2.7.New Organs and Limbs

Nano-manufactured medical devices will be of dramatic value to those who have suffered massive trauma. Take the case of a patient with a crushed or severed spinal cord high in the back or in the neck. The latest research gives hope that when such patients are treated promptly after the injury, paralysis may be at least partially avoidable, sometimes. But those whose injuries weren't treated -including virtually all of today's patients-remain paralyzed.

With the techniques discussed above, it will become possible to remove scar tissue and to guide cell growth so as to produce healthy arrangements of the cells on a microscopic scale. With the right molecular-scale poking and prodding of the cell nucleus, even nerve cells of the sorts found in the brain and spinal cord can be induced to divide. Where nerve cells have been destroyed, there need be no shortage of replacements. These technologies will eventually enable medicine to heal damaged spinal cords, reversing paralysis.

The ability to guide cell growth and division and to direct the organization of tissues will be sufficient to regrow entire organs and limbs, not merely to repair what has been damaged. This will enable medicine to restore physical health despite the most grievous injuries.

III.1.5.2.8. First Aid

Throughout the centuries, medicine has been constrained to maintain functioning tissues, since once tissues stop functioning, they can't heal themselves. With molecular surgery to carry out the healing directly, medical priorities change drastically—function is no longer absolutely necessary. In fact, a physician able to use molecular surgery would prefer to operate on nonfunctioning, structurally stable tissue than on tissue that has been allowed to continue malfunctioning until its structure was lost.

Brain tumors are an example: They destroy the brain’s structure, and with it the patient’s skills, memories, and personality. Physicians in the future should be able to immediately interrupt this process, to stop the functioning of the brain to stabilize the patient for treatment.

Techniques available today can stop tissue function while preserving tissue structure. A variety of procedures can stabilize tissues on a long-term basis. These procedures enable many cells—but not whole tissues—to survive and recover without help; advanced molecular repair and cell surgery will presumably tip the balance, enabling cells, tissues, and organs to recover and heal. When applied to stabilizing a whole patient, such a condition can be called "biostasis". A patient in biostasis can be kept there indefinitely until the required medical help arrives. So in the future, the question "Can this patient be restored to health?" will be answered "Yes, if the patient’s brain is intact, and with it the patient’s mind."

III.1.6. The Threat of New Developing Diseases

New diseases continue to appear today as they have throughout history. Today’s population, far larger than that of any previous century, provides a huge, fertile territory for their spread.

AIDS for example: Could it change and give rise to a form able to spread, say, as colds do? Nobel Laureate Howard M. Temin has said, "I think that we can very confidently say that this can’t happen."Nobel Laureate Joshua Lederberg, president of Rockefeller

University in New York City, replied," I don't share your confidence about what can and cannot happen." He points out that "there is no reason a great plague could not happen again. . .We live in evolutionary competition with microbes—bacteria and viruses. There is no guarantee that we will be the survivors."

III.1.7.Nanotechnology Facing the Threats

Immune machines could be set to kill a new virus as soon as it is identified. The instruments nanotechnology brings will make viral identification easy. Some day, the means will be in place to defend human life against viral catastrophe.

From eliminating viruses to repairing individual cells, improving our control of the molecular world will improve health care. Immune machines working in the bloodstream seem about as complex as some engineering projects human beings have already completed—projects like large satellites. Other medical nanotechnologies seem to be of a higher order of complexity.

III.1.8. Automated Engineering

To succeed in designing a nanomachine capable of entering a cell, reading its DNA, finding and removing a deadly viral DNA sequence, and then restoring the cell to normal within a reasonable number of years, we may need to automate much of the engineering process, including software engineering. Today's best expert systems are nowhere near sophisticated enough. The software must be able to apply physical principles, engineering rules, and fast computation to generate and test new designs. Call it "automated engineering".

Automated engineering will prove useful in advanced nanomedicine because of the sheer number of small problems to be solved. The human body contains hundreds of kinds of cells forming a huge number of tissues and organs. Taken as a whole (and ignoring the immune system), the body contains hundreds of thousands of different kinds of molecules. Performing complex molecular repairs on a damaged cell might require solving millions of separate, repetitive problems. The molecular machinery in cell surgery devices will need to be controlled by complex software, and it would be best to be able to delegate the task of writing that software to an automated system. Until then, or until a lot of more conventional design work gets done, nanomedicine will have to focus on simpler problems.

III.1.9. Aging

The deterioration that comes with aging is increasingly recognized as a form of disease, one that weakens the body and makes it susceptible to a host of other diseases.

Some researchers believe that aging is primarily the result of a fairly small number of regulatory processes, and many of these have already been shown to be alterable. If so, aging may be tackled successfully before even simple cell repair is available. But the human aging process is not well enough understood to enable a confident projection of this; for example, the number of regulatory processes is not yet known. A thorough solution may well require advanced nanotechnology-based medicine, but a thorough solution seems possible. The result would not be immortality, just much longer, healthier lives for those who want them.

III.1.10. Restoring Species

A challenging problem related to medicine (and to biostasis) is that of species restoration. Today, researchers are carefully preserving samples from species now becoming extinct.

Each cell typically contains the organism's complete genetic information, but what can be done with this? Many researchers today collect samples for preservation thinking only of the implantation scenario: one that they know has already been made to work. Other researchers are taking a broader view: the Center for

Genetic Resources and Heritage at the University of Queensland is a leader in the effort. Daryl Edmondson, coordinator of the gene library, explains that the center is unique because it will "actively collect data. Most other libraries simply collate their own collections." Director John Mattick describes it as a "genetic Louvre" and points out that if genes from today’s endangered species aren’t preserved, "subsequent generations will see we had the technology to keep [DNA] software and will ask why we didn’t do it." With this information and the sorts of molecular repair and cell-surgery capabilities we have discussed, lost species can someday be returned to active life again as habitats are restored.

III.2. Cancer and Nanotechnology

"Small is beautiful" and for anyone who believes in nanotechnology "small is powerful" and with the arrival of nanotechnology "small has become revolution".

This review article explains the part and role played by nanotechnology on cancer therapy. Nanotechnology will change the very foundations of cancer diagnosis, treatment and prevention.

III.2.1. Nanodevices

Nanodevices are smaller than human cells (10,000 – 20,000 nm in diameter) and organelles and similar in size to large noninvasive access to the interior of the living cell offers the opportunity for unprecedented gains on both clinical and basic research frontiers.

Nanoscale devices smaller than 50nm can easily enters most cells, while those smaller than 20 nm can transit out of blood vessels. As a result, nanoscale devices can readily interact with biomolecules on both the cell surface and within the cell, often in ways that do not alter the behavior and biochemical properties of those molecules.

III.2.2. Nanotechnology and Diagnostics

Today, cancer related nanotechnology research is proceeding on two main fronts:

1.Laboratory based diagnostics

2.In vivo diagnostics and therapeutics

Nanoscale devices designed for laboratory use rely on many of the methods developed to construct computer chips. For example 1-2nm wide wires built on a micron scale silicon grid can be coated with monoclonal antibodies directed against various tumor markers. With minimal shape preparation, substrate binding to even a small number of antibodies produces a measurable change in the device's conductivity, leading to a 100-fold increase in sensitivity over current diagnostics techniques.

Nanoscale cantilevers, constructed as part of a larger diagnostic device, can provide rapid and sensitive detection of cancer related molecules.

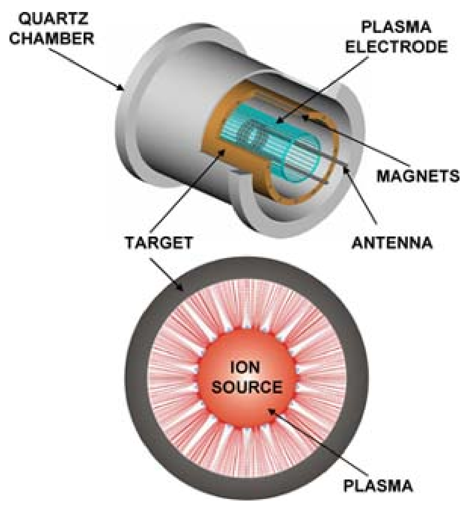

Figure (4): Nanoscale cantilevers

Nanoscale cantilevers can be coated with molecules capable of binding specific substrates, DNA complementary to a specific gene sequence, for example. Such micron sized devices, can detect single molecules of DNA or protein. Researchers have also been developing a wide variety of nanoscale particles to serve as diagnostic platform devices.

Already, research has shown that nanoscale delivery devices, such as dendrimers (spherical, branched polymers), silica coated miscelles,
ceramic nanoparticles, and cross linked liposomes, can be targeted to cancer cells. This is done by attaching monoclonal antibodies or

cell surface receptor ligands that binds specifically to molecules found on the surface of cancer cells, such as high affinity folate receptor and luteinizing hormone releasing hormone (LH-RH) or molecules unique to endothelial cells that become co-opted by malignant cells, such as integrin.v.3.

Once they reach their target, the nanoparticles are rapidly taken in to cells. As efforts in proteomics and genomics uncover other molecules unique to cancer cells, targeted nanoparticles could become the method of choice for delivering anticancer drugs directly to tumor cells and their supporting endothelial cells. Eventually it should be possible to mix and match anticancer drugs with anyone of a number of nanotechnology based delivery vehicles and targeting agents, giving researchers the opportunity to tune the therapeutic properties without needing to discover new bioactive molecules.

III.2.3. Nanotechnology and Cancer Therapy

On an equally unconventional front, efforts are focused on constructing robust “smart” nanostructures that will eventually be capable of detecting malignant cells in vivo, pinpointing their location in the body, killing the cells, and reporting back that their payload has done its job. The operative principles driving these current efforts are modularity and multifunctionality, i.e., creating functional building blocks that can be snapped together and modified to meet the particular demands of a given clinical situation.

A good example from the biological world is a virus capsule, made from cowpea mosaic virus and cockhouse virus as potential Nanodevices. Optical probe silica shell of coat protein that assemble into a functional virus capsule offer a wide range of chemical functionality that could be put to use to attach homing molecules such as monoclonal antibodies or cancer cell specific receptor antagonists, and reporter molecules such as magnetic resonance imaging (MRI) contrast agents, to the capsule surface, and to load therapeutic agents inside the capsule.

While such work with naturally existing nanostructures is promising, chemists and engineers have already made substantial progress turning synthetic materials into multifunctional nanodevices. Dendrimers, 1-10nm spherical polymers of uniform molecular weight made from branched monomers, are proving particularly adept at providing multifunctional modularity. In one elegant demonstration, investigators attached folate which targets the high affinity folate receptor found on some malignant cells, the indicator fluorescein and either of the anticancer drugs methotrexate or paclitaxel to a single dendrimers.

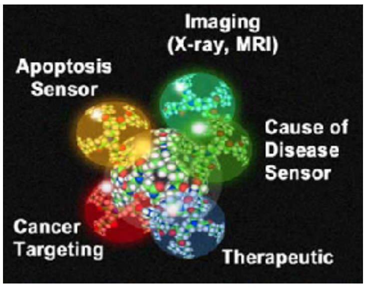

Figure (5): Dendrimer used in Cancer therapy

Both in vitro and in vivo experiments showed that this nanodevice delivered its therapeutic payload specifically to folate receptor positive cells while simultaneously labeling these cells for fluorescent detection.

Subsequent work, in which fluorescent indicator of cell death was linked to the dendrimers, provided evidence that the therapeutic compound was not only delivered to its target cell but also produced the desired effect. Already, some dendrimer based constructs are making their way toward clinical trials for treating a variety of cancers. Such multifunctional nanodevices, sometimes referred to as "nanoclinics", may also enable new types of therapeutic dendrimers can serve as versatile nanoscale platforms for creating multifunctional devices capable of detecting cancer and delivery drugs. Contrast agents (X-ray, MRI) cell death sensor therapeutic cancer cell targeting approaches or broader application of existing approaches to killing malignant cells.

For example: silica coated lipid micelles containing LH-RH as a targeting agent has been used to deliver iron oxide particles to LH-RH receptor positive cancer cells. Once these so called nanoclinics have been taken up by the target cell, they can not only be imaging using MRI, but can also be turned into molecular scale thermal scalpels: applying a rapidly oscillating magnetic field causes the entrapped Fe_2O_3 molecules to become hot enough to kill the cell.

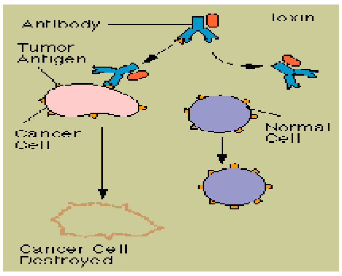

Figure (6): Nanoclinics destroying Cancer cells

The critical factor operating here is the nanoparticles can entrap 10,000 or more Fe_2O_3 molecules, providing both enhanced sensitivity for detection an enough thermal mass to destroy the cell. From Nicolas Beeson, university of Michigan center for Biologic Nanotechnology Drug Delivery Indicator “smart” dynamic nanoplatforms have the potential to change the way cancer is diagnosed, treated and prevented. The outside of such “nanoclinics” could be decorated with a tumourhoming monoclonal antibody and coated with polyethylene glycol (PEG) to shield the device from immune system detection.

The polymer matrix of such particles could be loaded with contrast agents, which would provide enhanced sensitivity for pinpointing tumor location within the body, and various types of therapeutic agents, such as reactive oxygen generating photodynamic sensitizers that would be activated once the particle detected a malignant cell. From Raoul Kopelman and Martin Philbert, University of Michigan photo sensitizers used in photodynamic therapy, in which light is used to generate reactive oxygen locally within tumors, have also been entrapped in targeted nanodevices.

The next step in this work is to also entrap a light generating system, such as the luciferin-lusiferase pair, in such a way as to trigger light production only after the nanoparticles have been taken up by a targeted cell. If successful, such an approach would greatly extend the usefulness of photodynamic therapy to include treatment of tumours deep within the body. Such multifunctional nanodevices hold out the possibility of radially changing the practice of oncology, perhaps providing the means to survey the body.

For the first signs of cancer and deliver effective therapeutics during the earliest stages of the disease. Certainly, researchers envision a day when a smart nanodevice will be able to fingerprint a particular cancer and dispense the correct drug at the proper time. In a malignant cell's lifecycle, making individualized medicine a reality at the cellular level.

III.2.4. Nanotechnology Platform

An important aspect of biomedical nanotechnology research is that most systems are being designed as general platforms that can be used to create a diverse set of multifunctional diagnostic and therapeutic devices.

Nanotechnology is providing a critical bridge between the physical sciences and engineering, on the one hand, and modern molecular biology on the other. Materials scientists, for example, are learning the principles of the nanoscale world by studying the behavior of biomolecules and biomolecular assemblies. In return, engineers are creating a host of nanoscale tools that are required to develop the systems the biology models of malignancy needed to better diagnose, treat and ultimately prevent cancer.

National Nanotechnology Standardisation Laboratory for Cancer Therapy

As part of its cancer nanotechnology program the National Cancer Institute is establishing a National resource laboratory that will provide critical infra structure support to this rapidly developing field. The National Nanotechnology Standardization Laboratory (NSL) will fill a major resource gap in biomedical nanotechnology by providing nanodevice assessment and standardization capabilities that many experts have identified as a critical realm.

The basic functions carried out by the NSL will include:

1. GMP synthesis of sizable quantities of a variety of nanoparticles and nanodevices
2. Characterization of nanoparticles and devices
3. Functionalization of nanoparticles
4. Development of tools and methods for characterizing both native and functionalized nanoparticles
5. Creation of reference standards and release specifications

III.2.6.CONCLUSION

To help meet the goal of eliminating death and suffering from cancer by 2015, The National Cancer Institute (NCI) is engaged in efforts to harness the power of nanotechnology to radially change the way we diagnose, image, and treat cancer. Already, NCI programs have supported research on novel nanodevices capable of one or more clinically important functions, including detecting cancer at its earliest stages, pinpointing its location within the body, delivering anticancer drugs specifically to malignant cells, and determining if these drugs are killing malignant cells.

"Nanotechnology is going to be the shaping of the future in cancer therapy"

III.3. Nanotechnology in Food and Agriculture

Manufactured nanoparticles, nano-emulsions and nano-capsules are now found in agricultural chemicals processed foods, food packaging and food contact materials including food storage containers, cutlery and chopping boards. Friends of the Earth organization have identified 104 of these products, which are now on sale internationally.

Against the backdrop of dangerous climate change, there is growing public interest in reducing the distances that food travels between producers and consumers, yet nanotechnology appears likely to promote transport of fresh and processed foods over even greater distances.

Materials now used in nutritional supplements, food packaging and food contact materials, have been found to be highly toxic to cells in test tube studies. Preliminary environmental studies also suggest that these substances may be toxic to ecologically important species such as water fleas.

Yet there is still no nanotechnology-specific regulation or safety testing required before manufactured nanomaterials can be used in this field. Nanotechnology also poses broader challenges to the development of more sustainable food and farming systems.

III.3.1. Nanofood

The term "nanofood" describes food which has been cultivated, produced, processed or packaged using nanotechnology techniques or tools, or to which manufactured nanomaterials have been added.

Examples:

1-Nanoparticles of iron or zinc.

2-Nanocapsules containing ingredients like co-enzyme Q10 or Omega 3.

We will be able to eat any food, no matter how rich. Sugar ، salt, fat, cholesterol , all the things we love but have to consume in moderation now will have no restrictions on them in future. All food will be nutritious; the sole criterion for choosing meals will be the taste.

Figure (7): Examples of the current use of nanomaterials in agriculture, foods and food packaging

Type of Product	**Product name and manufacturer**	**Nanocontent**	**Purpose**
Nutritional supplement	Nanoceuticals 'mycrohydrin' powder ، RBC Lifesciences	Molecular cages 1-5 nm diameter made from silica-mineral hydride	Nano-sized mycrohydrin has increased potency and bioavailability. Exposure to moisture releases H- ions and acts as a powerful

		complex	antioxidant.
Nutritional drink	Oat Chocolate Nutritional Drink Mix،Toddler Health	300 particles of iron (Sun Active Fe)	Nano-sized iron particles have increased reactivity and bioavailability.
Food contact material (cooking equipment)	Nano silver cutting board, A-Do Global	Nanoparticles of silver	Nano-sized silver particles have increased antibacterial properties.
Food contact materials (crockery)	Nano silver baby mug ، Baby Dream	Nanoparticles of silver	Nano-sized silver particles have increased antibacterial properties.
Food contact material (kitchenware)	Antibacterial kitchenware ، Nanocaretech/ NCT	Nanoparticles of silver	Nano-sized silver particles have increased antibacterial properties.
Food packaging	Adhesive for McDonald's burger containers ، Ecosynthetix	150-50nm starch nano-spheres	These nanoparticles have 400 times the surface area of natural starch particles. When used as an adhesive they require less water and thus less time and energy to dry.
Food additive	Aquasol preservative ، AquaNova	Nanoscale micelle (capsule) of lipophilic or water insoluble substances	Surrounding active ingredients within soluble nanocapsules increases absorption within the body (including individual cells).
Plant growth treatment	PrimoMax x, Syngenta	100nm particle size emulsion	Increases potency of active ingredients, potentially reducing the quantity to be applied.

Manufactured nanomaterials are already used in some food products، nutritional supplements, many packaging and food storage applications and some agricultural inputs (e.g. fertilizers and pesticides. In this report we use the term pesticide to mean any chemical used to control either animal or plant pests, i.e. including both pesticides and herbicides.

Friends of the Earth’s organization investigation into the use of nanotechnology across the food chain reveals that foods which contain manufactured nanomaterial ingredients and additives are not the stuff of science function but are already found on supermarket shelves.

Estimates of commercially available nanofoods vary widely; nanotechnology analysts estimate that between 150-600 nanofoods and 400-500 nano food packaging applications are already on the market.

III.3.1.1. Nanotechnology and food processing

III.3.1.1.1. Nanofood now no longer just a vision:

The vision of nanofoods described by nanofood technologists includes liquids that can change color, taste and texture at the press of a microwave button, and products customized to respond to an individual’s health and nutritional requirements. Yet while such applications can best be described as "next generation" nanofoods products are far closer to commercialization.

Nestlé and Unilever are reported to be developing a nano-emulsion based ice cream with a lower fat content that retains a fatty texture and flavor.

Nano-nutritional additives are already being used to boost the vitamin and mineral content of some processed foods and to speed up the manufacturing of processed meats.

III.3.1.1.2. **Processing aids:**

Nano-encapsulated active ingredients including vitamins and fatty acids are now sold commercially for use in processing and preservation of beverages, meats ،cheese and other foods (Aquanova undated). Nanoparticles and particles a few hundred nanometres in size are added intentionally to many foods to improve flow properties (e.g. how well it pours), color and stability during processing, or to increase shelf life .

Examples:

1-Alumino-silicates are commonly used as anti-caking agent, granular or powdered processed foods.

2-Anatase titanium dioxide is a common food whitener and brightener additive, used in confectionery, some cheeses and sauces.

In bulk form (conventional, larger particle size), these food additives are usually biologically inert and are considered by regulators the European Union and elsewhere to be safe for human consumption

However, these regulators make no distinction between particle size when assessing the safety of food additives ،despite the growing evidence that many nano-scale additives show heightened toxicity risks.

Example: 200nm particles of titanium dioxide have been found to be immunologically active and could cause inflammationScientists have suggested that particles a few hundred nanometres in size that are used as food additives may be a factor in the rising incidence of auto-immune diseases like irritable bowel syndrome and Crohn’s disease

III.3.1.1.3. Nutritional additives:

Nutritional additives are another growing source of nanoparticles in foods. The institute of Medicine of the U.S National Academy of Sciences defines "functional foods", also known as "nutraceuticals":
(A combination of the words nutrition and pharmaceutical) as: "foods that provide a health benefit beyond the traditional nutrients contain".

Dairy products, cereals, breads and beverages are now fortified with vitamins, minerals such as iron, magnesium or zinc, probiotics, bioactive peptides ،antioxidants, plant sterols and soy. Some of these active ingredients are now being added to foods as nanoparticles or particles a few hundred nanometres in size.

Active ingredients include vitamins, preservatives and enzymes. These have until recently been added to foods in microscale capsules, but are now also being produced in capsules thousands of times smaller in an effort to increase their potency.

For example: many of the commonly used Omega 3 food additives are micrometres in size, such as the 140-180 µm micro-encapsulated tuna fish oils used by Nu-Mega Driphorm® to fortify Australia’s Tip Top bread line

However, increasingly companies such as Aquanova and Zymes are offering Omega 3 in 30-40nm nano-capsules - an incredible 4,000 times smaller than the Nu-Mega range.

Aquanova’s Novasol range of nano-encapsulated bioactive ingredients also includes vitamins, co-enzyme Q10 ،isoflavones, flavonoids, carotenoids ،phyto-extracts, essential oils, preserving agents, food coloring substances and other bioactive substances.

The effectiveness of nutraceutical ingredients depends on preserving and enhancing their bioavailability.

Nano-sizing or nano-encapsulating active ingredients delivers greater bioavailability ،improved solubility and increased potency compared to these substances in larger or micro-encapsulated form

III.3.1.1.4. Modern food processing methods produce nanoparticles:

Processing techniques which produce nanoparticles, particles up to a few hundred nanometres in size, and nano-scale emulsions are used in the manufacture of salad dressings ،chocolate syrups, sweeteners, flavoured oils, and many other processed foods.

These processing techniques are used precisely because the textural changes and flow properties they produce are attractive to manufacturers.

Nanopathology researcher **Dr Antonietta Gatti** has found that many food products contain insoluble, inorganic nanoparticles and microparticles that have no nutritional value, and which appear to have contaminated foods unintentionally, for example as a result of the wear of food processing machines or through environmental pollution.

Gatti and colleagues tested breads and biscuits and found that about 40% contained inorganic nanoparticle and microparticle contamination.

The potential for such foods to pose new health risks must be investigated in order to determine whether or not related new food safety standards are required. Just as a better understanding of the health risks of incidental nanoparticles in air pollution have resulted in efforts to reduce air pollution, improved understanding of the health risks associated with incidental nanoparticle contaminants in foods may also warrant efforts to reduce incidental nanoparticles ‘contamination of processed foods.

III.3.1.2. Nanotechnology used for food packaging and food contact materials

III.3.1.2.1. Extending the shelf-life of packaged Foods:

One of the earliest commercial applications of nanotechnology within the food sector is in packaging.

Between 400 and 500 nano-packaging products are estimated to be in commercial use now, while nanotechnology is predicted to be used in the manufacture of 25% of all food packaging within the next decade.

How to extend shelf-life of packaged foods?

By improving the barrier functions of food packaging to reduce gas and moisture exchange and UV light exposure.

For example: DuPont has announced the release of a nano titanium dioxide plastic additive "DuPont Light Stabilizer 210" which could reduce UV damage of foods in transparent packaging. In 2003, over 90% of nano packaging (by revenue) was based on nano-composites, in which nanomaterials are used to improve the barrier functions of plastic wrapping for foods, and plastic bottles for beer ، soft drinks and juice.

Nano-packaging can also be designed to release antimicrobials, antioxidants, enzymes, flavors and nutraceuticals to extend shelf-life.

III.3.1.2.2. Edible Nano coatings:

Most of us are familiar with the waxy coatings often used on apples .Now nanotechnology is enabling the development of nanoscale edible coatings as thin as 5nm wide, which are invisible to the human eye. Edible nano coatings could be used on meats, cheese, fruit and vegetables, confectionery, bakery goods and fast food. They could provide a barrier to moisture and gas exchange, act as a vehicle to deliver colours, flavours ،antioxidants, enzymes and anti-browning agents, and could also increase the shelf life of manufactured foods, even after the packaging is opened.

III.3.1.2.3. Chemical release Nano packaging:

It enables food packaging to interact with the food it contains. The exchange can proceed in both directions. Packaging can release nanoscale antimicrobials, antioxidants ،flavours, fragrances or nutraceuticals into the food or beverage to extend its shelf life or to improve its taste or smell. Conversely, nano packaging using carbon nanotubes is being developed with the ability to ‘pump ‘out oxygen or carbon dioxide that would otherwise result in food or beverage deterioration.

Nano packaging that can absorb undesirable flavours is also in development.

III.3.3.1.4. Nano-based antimicrobial packaging and food contact materials:

Distinct from trigger-dependent chemical release packaging, designed to release biocides in response to the growth of a microbial population, humidity or other changing conditions, other packaging and food contact materials incorporate antimicrobial nanomaterials, that are designed not to be released, so that the packaging itself acts as an antimicrobial .

These products commonly use nanoparticles of silver although some use nano zinc oxide or nano chlorine dioxide.

Nano magnesium oxide, nano copper oxide, nano titanium dioxide and carbon nanotubes are also predicted for future use in antimicrobial food packaging.

III.3.3.1.5. Nano-sensor and track and trace packaging :

Packaging equipped with nano sensors is designed to track either the internal or the external conditions of food products ، pellets and containers throughout the supply chain. For example, such packaging can monitor temperature or humidity over time and then provide relevant information on these conditions.

Companies as diverse as Nestlé, British Airways, MonoPrix Supermarkets, 3M and many others are already using packaging equipped with chemical sensors, and nanotechnology is offering new and more sophisticated tools to extend these capabilities and to reduce costs.

Nanotechnology is also enabling sensor packaging to incorporate cheap radio frequency identification (RFID) tags. Unlike earlier RFID tags, nano-enabled RFID tags are much smaller , can be flexible and are printed on thin labels. This increases the tags' versatility.

For example: Enabling the use of labels which are effectively invisible and thus enables much cheaper production .

Other varieties of nano-based track and trace packaging technologies are also in development.

III.3.2. Nanotechnology used in agriculture

Nanotechnology is introducing a new array of potentially more toxic pesticides, plant growth regulators and chemical fertilizers than those in current use at a time when we should be increasing our support for more sustainable food systems. By providing new tools for gene manipulation, nanotechnology is also kely to expand the genetic engineering of crops. Such systems may also result in larger scale agribusiness employing ever fewer workers.

III.3.2.1. Nano agrochemicals are already in commercial use:

Some of the first nano agrochemicals in development are nano-reformulations of existing pesticides, fungicides, plant, soil and seed treatments.

Joseph and Morrison (2006) observed that many companies make formulations which contain nanoparticles within the 100-250 nm size range that are able to dissolve in water more effectively than existing ones (thus increasing their activity). Other companies employ suspensions of nanoscale particles (nanoemulsions), which can be either water or oil-based and contain uniform suspensions of pesticidal or herbicidal nanoparticles in the range of 200-400 nm.

III.3.2.2.Nano-genetic manipulation of agricultural crops andanimals:

For decades, molecular biologists have sought to genetically engineer microbes, plants and animals, but have been faced with many technical limitations and hurdles. Nanobiotechnology now appears to offer a new suite of tools to manipulate the genes of plants or animals by using nanoparticles, nanofibres and nanocapsules, rather than using viral vectors, to carry foreign DNA and chemicals into cells.

These nanomaterials can transport a much larger number of genes
as well as the chemicals that trigger gene expression. Theoretically, the use of nanotechnology also offers greater control over the release of DNA at the target site.

General Applications of Nanotechnology in Agriculture

1. Crop improvement
2. Anobiotechnology
3. Analysis of gene expression and Regulation
4. Soil management
5. Plant disease diagnostics
6. Efficient pesticides and fertilizers
7. Water management
8. Bioprocessing
9. Post Harvest Technology
10. Monitoring the identity and quality of agricultural produce
11. Precision agriculture

III.3.2.4. Conclusion

Given the potentially serious health and environmental risks and social implications associated with nanofood and agriculture, Friends of the Earth organization, Australia ،Europe and United States are calling for:

A moratorium on the further commercial release of food products, food packaging, food contact materials and agrochemicals that contain manufactured nanomaterials until nanotechnology-specific safety laws are established and the public is involved in decision making**.**

III.4. Nanotechnology and water

Freshwater looks like it will become the oil of the 21st century, scarce, expensive and fought over. While over 70 % of the Earth's surface is covered by water, most of it is unusable for human consumption. According to the Government of Canada's Environment Department (a great resource for facts and all kinds of aspects about water), freshwater lakes, rivers and underground aquifers represent only 2.5 % of the world's total freshwater supply. Freshwater is also very unevenly distributed. The United Nations has compared water consumption with its availability and has predicted that by the middle of this century between **2** billion and **7** billion people will be faced with water scarcity. Due to the shortage of safe drinking water in much of the world, there are 3.3 million deaths every year from diarrheal diseases caused by E. coli, salmonella and cholera bacterial infections, and from parasites and viral pathogens. In fact, between 1990 and 2000, more children died of diarrhea than all the people killed in armed conflicts since the Second World War.

The use of nanotechnologies in four key water industry segments that are:

1. Monitoring
2. Desalinization
3. Purification
4. Wastewater treatment

III.4.1. Difference between purification of water by nanotechnology and conventional methods

However, water purification technology is often complicated, requires sophisticated equipment and is expensive to run and maintain. Moreover, it usually requires a final costly disinfection stage. The Australian team suggests that nanotechnology could provide a simple answer to the problem.

III.4.2. How nanoparticles purify water?

Tiny particles of pure silica coated with an active material could be used to remove toxic chemicals, bacteria, viruses, and other hazardous materials from water much more effectively and at lower cost than conventional water purification methods, according to researchers writing in the current issue of the International Journal of Nanotechnology.

The researchers have investigated how silica particles can be coated easily with a nanometer-thin layer of active material based on a hydrocarbon with a silicon-containing anchor. The coating is formed through a chemical self-assembly process so involves nothing more than stirring the ingredients to make the active particles.

Peter Majewski and Chiu Ping Chan of the Ian Wark Research Institute, at the University of South Australia, explain that the availability of drinking quality water is fast becoming a major socio-economic issue across the globe, especially in the developing world.

These active particles, so called Surface Engineered Silica (SES), were then tested to demonstrate that they could remove biological molecules, pathogens such as viruses like the Polio virus, bacteria like Escherichia coli, and Cryptosporidium parvum, which is a waterborne parasite.

They point out that the filtration process occurs through an electrostatic attraction between the pathogens and the surface engineered particles.

The team's nanotech approach to water purification could help prevent disease and poisoning for potentially millions of people.

V. Limitations of Nanotechnology

Every time a technology solves a problem, it creates new problems. This doesn't mean that the change is neutral, or for the worse.

Molecular manufacturing and nanotechnology will bring far greater changes, placing far greater strains on our ability to adapt it offers the possibility of drastic change, a change in the means of production more fundamental than the introduction of industry, or of agriculture. Our economic and social structures have evolved around assumptions that will no longer be valid.

Nanotechnology may pose serious risks, environmental, manufacturing, political and security, educational gap, essential human, environmental, societal structure and human health risks.

IV.1. Human health risks

Several studies have shown that due to the high surface-area-to-volume ratio and higher reactivity of nanostructures, large doses can cause cells and organs to demonstrate a toxic response even when the material is non-toxic at the (larger) microscale or macroscale. Some nano-sized particles are able to penetrate the olphactory system, the liver and other organs, passing along nerve axons into the brain, nanomaterials may combine with iron or other metals, thereby increasing the level of toxicity and so pose unknown risks.

IV.2. Environmental risks

Nanostructures may have a significant impact on the environment due to the potential for bioaccumulation, particularly if they absorb smaller contaminants such as pesticides, cadmium and organics and transfer them along the food chain.

IV.3. Manufacturing risks

Radically new manufacturing methods may change the market, production levels and geographical distribution of industry, as well as the distribution of the work force. Also, workers potentially face greater exposure to the human health and safety risks.

IV.4. Educational gap risk

If the knowledge within scientific/industrial communities is not appropriately shared with regulatory agencies, civil society and the public, risk perception/management may not be based on the best available knowledge, innovative opportunities may be lost and public confidence in transparency and accountability may erode.

IV.5. Essential human and environmental risks

There is apprehension about the use of nanotechnology to fundamentally change how human and environmental biosystems work. Examples include further enhancements to genetic modification, devices to control the human brain and body, changes to the environment, human safety and quality of life.

V. Final Word

V.1. Market Potential

Nanotechnology is a global phenomenon, and no country wants to be left behind. Worldwide, there is a "nanorace" going on – with US, EU and Japan leading the pack. US government is spending over US$1 billion in nanotechnology research per year. EU is spending even more. Over the next four years however, Japan is expected to outspend USA and EU in terms of governmental funding. China, Germany and South Korea will also be receiving significant government funding. Total private and public spending for nanotechnology for 2008 will be at US$25 billion, $1 billion of which will be from venture capital.

The excitement in nanotechnology is understandable since it is expected to impact virtually every industry. These include life Science and healthcare (including medical devices, drug delivery, and therapeutics), chemicals and advanced materials, electronics and semiconductors, aerospace and defense, auto industry, textile, food, and printing and packaging industries. No country wants to be left behind.

The current market for nanotechnology products is estimated at around US$18 billion. The nanotechnology industry is expanding at a healthy pace of around 20% for the past few years and will continue to grow at a very healthy pace for quite some time. Since the potential of the market is so high and the technology has such great potential and ability to impact so many different industries, that we often see market figures of several trillion of dollars for nanotechnology – this of course refers to the market value of the end-products using nanotechnology.

V.2. About Egypt

There is a great chance for Egypt as a developing country to enter this race depending on its own NT scientists like Prof. Dr. Mustafa Al-Sayed and Prof. Dr. Muhammad Al-Nasha'i who will give Egypt the ability to be one of the countries that will develop the Future's worldwide most used technology…NT.

"Nanotechnology is a truth and promises it holds are stronger than fiction"

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