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- Publication of an editorial detailing the misconduct.
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# Internet of Things: Current Technological Review

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## *Abstract*

*This paper is a review of Internet of Things (IoT) with standards and industrial state-of-art approach. The purpose is to give insight into concept of "smart living", a concept that meets requirements of today's modern individuals and the society. Implementation of this new technology requires new hardware and software installed and run on devices ("things") connected to the Internet anytime and anywhere. In order to make possible this new technology for wide use, few technological, standards and legal issues need to be solved. Several key companies (such as Intel, Cisco, IBM, etc.) are proposing their own standards both in HW and SW solutions and the time will tell which standard will emerge as a dominant one. Standards are the key for world wide acceptance of this new technology, as well as underlying wireless data technologies such as WiFi, ZigBe, and new emerging 4G and 5G mobile technologies.*

*Keywords:* IoT, Internet of Things, "Intelligent Life", Smart Devices and Sensors

### 1. Introduction

The Internet of Things (IoT) refers to a broad technological vision enabling completely new concept of living called "intelligent life". Smart devices, smart phones, smart cars, smart homes, smart cities, smart transport, smart energy, smart industry, smart world are synonyms that describe new paradigm in the world of Internet. Internet of Things enables affluence of new opportunities different from the traditional one. New era in modern communication and internet will be outside of the traditional one. The IoT concept, hence, aims at making the Internet even more immersive including wide areas of possible applications.

The IoT is a system of technologies which can monitor the status of physical objects, capture meaningful data, and communicate that data over a (often wireless) network to a software application for analysis on a dedicated computer or to the cloud. Objects can be electronic devices such as a utility meter, organisms or a natural part of the environment such as an area of ground to be measured for moisture or chemical content. A smart device is associated with each object which provides the connectivity and a unique digital identity for identifying, tracking and communicating with the object. A sensor within or attached to the device is connected to the Internet by a local area connection (such as RFID, NFC or BTLE) and can also have wide area connectivity. Several companies are working on chip designs as well.

Typically, each data transmission from a device is small in size but the number of transmissions can be frequent. Each sensor will monitor a specific condition or set of conditions such as vibration, motion, temperature, pressure or utility quality. More applications have become feasible because the cost and size of such devices continue to decrease and their sophistication for measuring conditions keeps increasing. Technological giant Cisco predicts that 25 billion devices will be connected in the IoT by 2015, and 50 billion by 2020.

The IoTis a new technological ground that is not still standardized and therefore there is still no stable definition for it. The widely used definition is one from ITU and IERC as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network [1]. Simply stated, Internet of Things can be loosely defined as: "From anytime, anyplace connectivity for anyone, we will now have connectivity for anything" [2].

For the first time the Internet of Things concept was mentioned in 1999 by Kevin Ashton who was cofounder and executive director of the Auto-ID Center.

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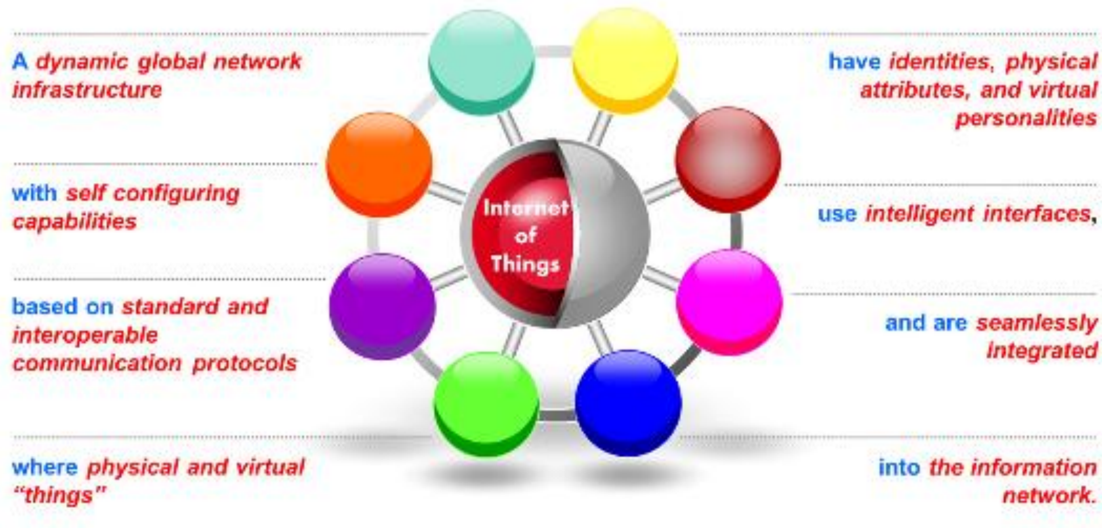


Figure 1.Definition of IoT [1]

Auto-ID Center represent collaboration between industry and private sector in order to work on new technology for tracking goods globally. The center closed door in 2003, but Auto-ID Labs continued working on the project. Now Auto-ID Labs are leading academic research network on Internet of Things. Auto-ID Labs are formed of seven research labs positioned on four continents, holding over 60 researchers and 15 professionals in leading positions.

Historical development of this idea started in 1999 as mentioned. Two years later in 2001 MIT Auto-ID Labs presented their vision of Internet of Things [3]. During the 2005 International Telecommunication Union (ITU) for the first time mentioned Internet of Things in a series of reports. In 2008 in Zurich the first conference was held on the Internet of Things. China has announced their interest in building smart cities, proposing Wuxi city representative of new idea called "Sensing China", during 2009. In June 2013 Kantara initiative was founded [4]. This group is formed in order to solve open questions and issues like discussion about ownership and identity relationships, object identifier, namespace, authentication, authorization, governance of data and privacy as specific open questions. Also in 2014,a state of the art report was published by Auto-Id Laboratory [5].

Even two years ago growth of Internet of Things was still considered with a skepticism. But several recent and key announcements(Net Labs, Google, Samsung Gear, developing and embedding of Smart Home feature into Apple's iOS), have made Internet of Things big business opportunity [1]. In addition, Cisco has conducted market research showing that Internet of Things has potential financial value of $14 trillion. All of that made Internet of Things even more attractive in today's research centers as well as industry.

## 2. Architecture

In new era sensor and network technologies will develop to meet new IoT challenge. Enormous data need to be stored and transferred in real time environment. What will be the platform or platforms that support vision of Internet of Things?

Cisco market prediction is that by 2020, there will be over 50 billion permanently connected "things", with over 200 billion with intermittent connections enabled. Solutions that exist now are not capable of supporting this number of users, so research groups are still trying to design architecture that will meet these challenges.

IoT until now suggested two types of architecture, three-tier and five-tier. In three-tier architecture authors propose simplified concept consisting of three layers. First layer is context aware, where sensors embedded in different technologies are collecting information and where different communication protocols are developed. Next layer is called network tier which connects different networks in order to transfer information collected by lower layer. Next layer is application layer which originally consists of three layers. This layer supports monitoring QoS, with different management systems depending on the application. Since three-tier architecture doesn't specify enough details as far as roles of each layer, five layers architecture is also proposed. This architecture is more specific, briefly describing functionalities of each layer. The first layer is perception layer which collects information about environment conditions like temperature, location of the sensor etc. On second transport layer all information collected on lower layer are transferred to the upper layer in order to process information. Processing layer than processes information in a way of storing and analyzing. The fourth layer is called application leyer. Here various types of application are described that will be used in IoT. At the top of architecture is business layer which purpose is management of services, privacy and choice of type of applications that will be used [6].

Other authors hold the view of Service Oriented Architecture (SOA) [7]. Here a Cloud-Assisted remote sensing approach is proposed with four layer architecture consisting of Fog Layer, Stratus Layer, Alto Cumulus Layer and Cirrus Layer. Fog Layer consists of "things" that sense and collect environment data. This layer serves for unique identification through IPv6, to connect "things" and for collection of data at one central point.

Stratus Layer is mid layer and consists of clouds managing migration of different clouds, ensuring functionalities for transferring data and for controlling agreed level of service with customers. Alto Cumulus Layer is intermediate layer between stratus and cirrus layer.
On this layer question related to pricing, policy and regulations are negotiated and agreed upon. At the top of architecture is Cirrus Layer with functions that serve clients. This layer can actually performs functions like customers entry point to the system allowing customers to set their own requirements regarding sensing, service models and providing online applications [8].

Globally, all mentioned architectures meet basic IoT concept, which is so far best described in architecture proposed by ITU-T and represented in figure 2.

Lower layer is device layer that contains devices, named sensors, for collecting information and gateways for sending collected information to upper layer. Network layer is responsible for choosing appropriate networks for transporting information over the Internet.

Service and application layer offers support for variety of different services. Application layer is service for different

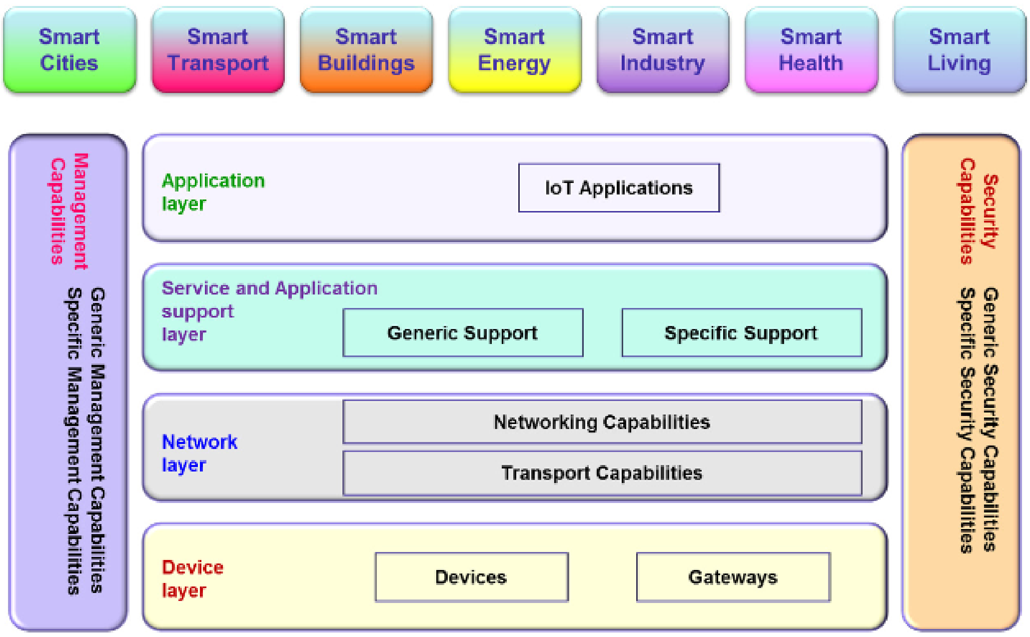


Figure 2.Internet of Things Architecture Proposed by ITU-T [1]

applications, management of transmitted data as well as monitoring of QoS (Quality of Service).

Beside all proposed architectures, there is also an additional proposal favored by the researchers, one proposed by EPCglobal Network. EPCglobal is a part of global non-profit high tech standardization bodies. In IofT context, the objective of the EPCglobal is production of recommendations for “EPCglobal Architecture Frame Work”. The EPCglobal is widely accepted and has support from other standardization organizations as well as industry. Results of their work are already available at [9].

### 3. Open Questions And Issues

Potential offered by the Internet of Things concept, makes it possible to develop a huge number of new applications, of which only a very small number exist today. The Internet of Things will lead to an increasing amount of data sources producing a tremendous amount of data related to a society. Here computers (“things”) will replace people in a way of gathering information which would benefit in less waste of time, lower material loss and reduced overall cost. Computers need to be empowered to see, hear, and smell the real world, observe, identify and understand without limitation of data entered by humans. This simple idea, brings a number of open questions like availability of technologies for implementation, addressing security and privacy issues, and the standardization.

***Technologies*** suitable for Internet of Things which exist today are short range Radio Frequency Identification (RFID) and Wireless Sensor Networks (WSN), plus few more in development. In current literature RFID is presented as technology which can implement the Internet of Things vision because of low cost and strong existing support from business community. RFID together with Near Field Communications (NFC) and Wireless Sensor and Actuator Networks (WSAN) are recognized as “the atomic components that will link the real world with the digital world” [10]. As an example, RFID technology is composed of a reader and several remote tags. Tags are characterized by unified 64-96 bit identifiers. These tags can be active or passive depending on energy consumption. Tags are small chips placed on different objects. There are four different kinds of tags commonly in use: low frequency tags (125 kHz or 134.2 kHz), high frequency tags(13.56MHz), UHF tags (868 MHz to 956MHz), and microwave tags (2.45GHz). WSAN is starting to play important role in deploying new services in Internet of Things technology. New application scenarios include healthcare, environment monitoring, agriculture. Another trend is moving from traditional sensor networks toward 6LoPAN/IPv6 standard that allows native connectivity of sensors to the Internet.

As mentioned earlier in the paper, ***Standardization*** is the first and still unsolved problem that needs to be solved if IoT is to take off as a technology. Many proposals already exist but none is globally accepted and adopted. Standardization proposals are provided by institutions like Auto-ID lab, ETSI, ISO, and ITU. Figures 1 and 2 illustrate all the details than need to be standardized and agreed upon.

Situation is similar with ***Addressing*** of IoT devices. Again many proposals and solutions already exist, but none has majority acceptance across the industries. Regarding the number of devices which will use Internet addressing, addressing problem becomes essential. Since IPv4 addressing space is exhausted, IPv6 is to be employed. IPv6 gives solution for existing internet devices intended for use in regular internet surroundings. The problem is that the IPv6 is still not adapted to work with Internet of Things. Essentially, IPv6 allows for 128 bits for addressing. This will be enough for RFID which uses only 64-96 bit identifiers and this possibility has been investigated. Out of IPv6 128 bits, it is proposed that first 64 bits are used for RFID identification and the last 64 for gateway between RFID and Internet. Proposed solutions for this issue are given in [8], [12], [13], [22].

***Gathering of information*** is next issue related to Internet of Things. Here we deal with "big data" issue. Regarding enormous number of devices which will be connected to the network (as stated earlier up to 50 billion by 2020), gathered information will be massive. Problems which arise with this amount of data are transmission, storage and processing of "big data". Transmitted amount of data varies from few kb up to several Mb. Today storage of information delivered through Internet costs around $10^{-9}$ euro per byte. Counting total number of devices which will be connected and amount of information retrieved, delivered and stored, leads to a conclusion that very demanding resources will be required to handle demanding IoT requirements [6].

***Security and privacy*** of IoT are also very questionable since major problems come from wireless communications which is vulnerable to attacks. Concept of privacy is closely related to authentication and authorization. More about this is discussed in [2]. Hence IoT systems need to be designed and implemented with adequate security and privacy protection. The threat to security and privacy may not be recognized to be as significant as in other types of networks since IoT devices have limited functionality and connectivity. But there are more points of possible intrusion and vulnerability in an IoT system. A system failure or hacker attack could have serious consequences, for example in energy or other utility infrastructure. For example, a hacker could target sensors at a water treatment facility to cause false readings on whether water is potable. Most utility infrastructure IoT systems will have only security concerns but there will also be some privacy issues. Hacking into a smart utility meter, for example, could reveal whether or not a family is at home. Consumer IoT systems will need to protect both privacy and security.

There will be liability issues if the IoT system fails or makes a wrong determination. Liability insurance will be needed by IoT components and systems vendors. Limiting liability by contract with a utility, state or local government or business may be feasible in the same way as for other equipment and software but contracts may not be possible in many consumer applications.

The way that IoT physical components are combined into a system and the related data analytics software can have significant business value. Intellectual property (IP) and patent protection is important. IoT system designers need to think both offensively and defensively in creating an IP strategy so they have the freedom to operate without a license from a third party and also provide a barrier to entry by a competitor. There already exist several thousand patent applications and over 100 patents issued in which the term "Internet of Things" appears when the US Patent and Trademark Office (USPTO) data base is searched. A flood of application is probably to follow both in USA, Europe and other parts of the world.

## 4. Applications

There are several application domains which will be impacted by Internet of Things. New domains and areas where IoT applications will likely improve quality of our lives are home, health, work, and agriculture in many different ways.

*The Home of Internet of Things*

In personal and home use sensors can be used for controlling refrigerators, washing machines, air conditioner, surveillance system, etc. Another example are smart utility meters that one can read online on the utility's web site. There are pilot programs of smart meters and related technology that already rolled out USA and Europe. Utilities consumption is measured hourly and data is transmitted on a wireless basis to the utility center several times a day. Both the utility and customers can track the use. Currently, however, only few percent of developed countries customers are equipped with such smart devices and the overall implementation is slow.

*The Agriculture of Internet of Things*

One specific application of Internet of Things is in food supply chain. In today's world food supply is critical for human kind. In order to provide enough food, efficient management of food need to be done. Management is very complex and starts from the production, processing, storage, distribution and consumption. In this chain it is very important to provide certain level of quality. IoT can help in proper traceability, visibility and controllability of agriculture. Sensors embedded in fields can control field conditions, collect information and send data using WiFi, mobile or some other technology to the main center where the overall food chain is managed. More on this is given under Utility IoT bellow.

*The Industrial Control of Internet of Things*

Next type of applications are in industrial control. For example, employees monitoring, work of elevators in a building, use of lightning, heating and other industrial or building systems. Using ZigBee technology wireless sensors and passive tags, a variety of indoor locations and employees can be monitored. Sensor can also be employed for monitoring level of toxic gas and oxygen levels inside closed rooms (chemical plants for example) to ensure safety of workers.

*The Traffic Control Internet of Things*

Further application in IoT area is in traffic control. Here, traffic and road condition data would be collected using sensors and communicated to traffic control centers and to drivers in a form of information and traffic advice. Same can be done at traffic intersections to control smartly traffic lights and reduce accidents, traffic jams and traffic casualties. Car generated pollution can be reduced, as well as car fuel consumption. Traffic information can be provided by sensor network to determine the best route.

*The Smart Cities of Internet of Things*

The application of the Internet of Things paradigm to the urban context is of particular interest, for forming Smart Cities. This will bring benefits in many areas like management and optimization of traditional public services, such as transport and parking, lighting, surveillance and maintenance of public areas, parks, preservation of cultural heritage, garbage collection, maintenance of hospitals, and schools. By 2020 more of the 60 percent of world population will live in urban cities. Development of this idea has already started through FP7 Smart Santander project as well as OUTSMART project. A smart city is defined as a city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rail/subways, airports, seaports, communications, water, and power, even major buildings, the city that can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its typically numerous citizens. So called “Padova” city plan for smart city development is described in [14]. According to Pike research (www.pikeresearch.com) smart city market is estimated at hundreds of billions of dollars by 2020. Reference [15] summarizes a project where 77 cities were analyzed based on different criteria like economy, mobility, environment, governance, people, living conditions, etc. This is all taken into account for defining and building a smart city. The project is supported by “Technische Universitat in Wien” and started in 2007, financed by public and private stakeholders.

*The Utilities of Internet of Things*

Specifically for a smart home we would need a smart utility meter (water, electricity, gas) that generates usage data. This is communicated wirelessly to the utility center for the software on their computers to analyze the data and report results on the web site for a user to view. In some pilot programs, the customer can view the data as it comes in, as well as compare their numbers with past use and city averages. The usage numbers should eventually alert the user to, say, water leak plus utility status could also be measured with another device which could identify a leak immediately, rather than letting water to be wasted. To find the location for repair, however, we would need to add sensors to measure pressure at various locations in home’s water system. The sensors would be connected to data analytics software in the cloud that would analyze the data transmitted in order to identify the location of the leak between two sensing points in my water system. This is a much more complex application than simply tracking water usage and illustrates the importance of the software applications needed in order to make sense of the transmitted data. The IoT can’t make it rain or snow or fix leaky pipes but it can help the supply problem by making water usage more efficient and less wasteful, particularly in places where water is scarce. The IoT can also help water be transported to the point of need with greater precision.

*More Utility Applications of Internet of Things*

To further expand on the utility example, the universe of utility IoT systems can be divided into infrastructure, governmental, business and consumer. The water infrastructure IoT will help improve a utility’s quality, supply, treatment, transportation and storage facilities such as reservoirs. The priority for action should be to deploy the IoT at the infrastructure level since the water savings will be the greatest and action should be the fastest. A utility should be able to justify the expenditure on the water savings particularly on the basis of planning for scarcity. State and local governments can save money and also have a major impact on supply by implementing the IoT for buildings and other uses like landscape irrigation. An IoT water management system for a large building or office park can help the manager monitor and manage water use more efficiently. Water cost savings and forced conservation will help drive adoption by businesses (including often related and important agricultural industry) and consumers but they will be looking for a clear return on investment.

A utility can use an IoT system to remotely determine the status and working condition of equipment (open or closed, on or off, full or empty, etc.). A gate can be opened or closed or a pump turned on or off remotely to adjust the flow of water through a water transportation system. Pumps, gates and other equipment with moving parts in the water infrastructure can be monitored for vibration and other indications of failure. If a water pump is about to fail, the utility can be prompted to repair or replace it. An IOT-enabled water treatment plant can report if its filters are clean and functioning properly. The IoT can measure water pressure in pipes to find leaks faster in the water transportation system or the presence of certain chemicals in the water supply and maybe even organic contaminants like the ecoli which is often found especially in undeveloped areas.

Agriculture consumes lots of freshwater available in a country, with a large amount being wasted by leaky irrigation systems, inefficient field application methods and the planting of water intensive crops in the wrong growing location. The IoT has great potential to make water use smarter for the agricultural industry particularly in irrigation efficiency.

Another focus for water savings should be landscape irrigation in parks, medians and elsewhere. This is a major use of water in cities. Nationwide in USA, it is estimated to be nearly one-third of all residential water use and as much as half of this water is wasted due to runoff, evaporation or wind. An IoT landscape irrigation system is available in the market for public or private use which applies sophisticated data analytics to a wide variety of objects. Current weather data is combined with sensors for moisture and heat and other data such as the slope of the land, type of soil and the relative exposure to sunshine at a particular time.

*The Retail of Internet of Things*

This segment encompasses a broad range of services for end users. For example paying service can be accomplished using NFC technology, or intelligent shopping where based on your location your receive information about sales in shopping malls near you with special attention to customers habits. Also sensors can control shelves in stores signaling when shelf is empty and needs to be restocked.

*The Environment of Internet of Things*

In this area sensors play important role. Their functions include monitoring level of gases in preventing forest fire, or monitoring level of CO2 emission of factories, cars in defining a level of air pollution, or for monitoring level of snow preventing avalanche or landslide.

*The Health of Internet of Things*

Today modern society is responsible for changing healthcare model from hospital oriented toward home oriented. Including Internet of Things capabilities in this segment many effective solutions can be implemented. Some of the most important are in the area of tracking and monitoring patient status using WSN technology, in the area of remote service where diagnosis can be delivered through the Internet, patient information management where all data about patient are stored at one central place and can be reached through the Internet anytime, anywhere.

*Additional Area for Internet of Things*

Other application areas include: smart parking of parking places free for car parking in the city, monitoring of vibrations and conditions of material in building or some special places and monuments, controlling level of noise in the cities, in particular in centers and densely inhabited city parts, monitoring of congestion and optimization of driving and pedestrian routes, suggestions for shopping in shopping malls in a form of an advice based on customer habits, goods availability, etc.

## 5. SENSORS

Sensors play important role in Internet of Things technology, making it almost human with their “eyes” and “ears” features. It is not surprising that global companies are planning to invest huge amounts of money into smart sensors development. The sensor production worldwide will expand next few years, especially in area of energy and mining (33%), power and utilities (32%), automotive (31%) since many sensors are going to be embedded in the road and car for accident avoidance and hands free driving. Plans are that production of sensors in area of industrial will rise up to 25%, hospitality 22%, retail 20%, [16].

As an example of a company working in smart sensors, Omron Company is working on developing sensors as a part of smart face-recognition cameras. The sensors will be used as a part of smart home. Possible application can be in area of management lights in home. For example, sensor can detect a man sleeping at smart home and reduce level of light, possibly turning it down.

Another example is several manufacturers which started production of multi-sensor platforms integrating several sensing elements. For example, one self-tracking sensor contains several sensing elements like GPS sensor for positioning, temperature sensor for temperature of a body, heart rate sensor for measuring heart rate and blood pressure, accelerometer etc. This kind of sensor is already used in casual and professional sports, and sold by Nike, RunKeeper, Fitbit and other. In addition, “smart-watches” and “smart-glasses” are developed by Google and Apple and are expected to be widely used, [17].

In this paper (see Appendix) we also present a quick introduction of our own and new low power wireless sensor network which may be a future candidate for an IoT for certain sensor applications. We will elaborate on this in details in the subsequent paper.

## 6. Current Trends In Industry

Potential benefits from Internet of Things are almost endless. Internet of Things applications are changing the way people live, habits opening new opportunities for knowledge collecting and sharing as well as improving quality of life. These benefits are recognized by significant companies like Google, Apple, Intel and Cisco that positioned them in Internet of Things landscape, considering the Internet of Things biggest growth area as well as IP and innovation. Today many telecom operators consider that Internet of Things is becoming a core business focus measured by number of users connected in the network. Also part of this business is given to manufactures of mobile devices toward wider adoption of Internet of Things.

*Computer Chips for Internet of Things*

Industry Internet of Things leaders AT&T, Cisco, GE, Dell, and IBM are working with Intel to create solutions that give developers and customer flexibility to help drive market adoption, [18]. This decision is based on prediction that by the end of 2020, 50 billion of devices will be connected which will bring multi-trillion dollars of benefit for companies. Cisco even now offers solutions for smart cities, manufacturing, mining oil and gas as well as in physical security solutions, industrial networking and embedded networks [19]. IBM is also part of big alliance approaching Internet of Things vision. IBM is investing linkages between Information of Things and IBM Smarter Commerce, IBM Smarter Analytics [20]. Launching of new technology brings revolution in all parts of information and communication industry. Companies like Intel and AMD are challenged to design new chips that will conform to the requirements of the new technology. AMD has unveiled “company’s embedded chip roadmap for 2014”. Chips for embedded system are a key growth area intended for need of Internet of Things. After this message sent from AMD, Intel's CEO responded with their visionannouncing that company is in a phase of developing a new set of chips called Quark. Quark will be one-fifth of the size of use one-tenth of the power in comparison with their best existing chips. Cisco as a market leader launched nPower X1, processor that contains 4 billion of transistors offering 400Gbps throughput. These new technologiesare expected to bring huge profits to these companies. AMD and ARM have already announced that they expect grow from $11.6 billion in 2014 to $15.5 billion in next two years. All brought by the prospects of IoT.

Looking beyond simple vision of Internet to Things are Cognitive IoT, Cloud Connectivity for Internet of Things and Cloud-Assisted remote sensing CARS, that already have some features of Internet of Things.

*Cognitive Internet of Things*

Current research in cognitive area focuses on how to make sensors to see, hear smell and connect physical things around. This leads to development of new paradigm called Cognitive Internet of Things. New idea brings "brain" in the system which means that objects can learn about behavior, think about processes and understand different worlds around. Possible applications of this new concept can be in home, safety, health, all in order to enhance "intelligent life". The author in paper [21] gives definition of Cognitive Internet of Things and proposes architecture, where system relays on four layers: sensing control layer, data-semantic-knowledge layer, decision-making layer, and service evaluation.

*Cloud Connectivity for Internet of Things*

Number of devices connected to the Internet is rising every day. Most devices connect usingWiFi and WLAN solutions. Since Bluetooth and WLAN are two commonly used technologies for connecting to Internet, authors in paper [7] propose new Bluetooth technology for "things" connecting. Bluetooth 4.0 has a special extension for Bluetooth Low Energy which makes this technology suitable for low power sensors in the network. Constrained Application Protocol is protocol developed on application layer intended to be used for web services working with very simple devices with low power consumption. Using Constrained Application Protocol (CoAP) and Service Oriented Architecture (SOA) makes it possible to connect devices through different places in order to access local sensor cloud.

*Cloud-Assisted Remote Sensing (CARS)*

Another new concept in IoT paradigm is Cloud-Assisted Remote Sensing (CARS). CARS enables connection of distributed data, sharing of resources on global scale, real-time and remote access to data as well as pay-as-you-go concept. With development of CARS concept there is a big potential for development Internet of Everything (IoE) concept. IoE is a new trend in communication and Internet technologies that tries to connect everything on the Internet. Recent Cisco study has shown that this trend can give 14 trillion of dollars of net-profit value in the near future. CARS concept can bring benefits in remote tracking and monitoring category where possible applications can help in preventing environmental pollution, tracking of some rare species of animals, monitoring in health care, etc. Next category is real-time resource optimization and control where possible applications are in the area of traffic control and congestion avoidance, finding place for car parking. The last category is smart troubleshooting where we need to identify, diagnose and repair certain processes, with applications in many industries [8].

## 7. Conclusion

The Internet has changed dramatically the way we live. IoT idea pushes the Internet much further. This paper is a current review of basic aspects and concepts of new IoT paradigm, as well as an introduction of a NEW IoT based low power wireless sensor network protocol. Going back to 1999 when this term is used for the first time and then going in the future of 2025 and beyond, current IoT status and thinking is represented. Since the main vision is in providing "easy life" in "smart cities", this new concepts completely corresponds to the new requirements of modern society. This new trend is recognized by big companies like who have been most vocal in expressing their interest, which encompasses hardware (the things themselves), embedded software, communication and information services associated with the "things".

During the next five years, smart antennas, new IoT related wireless technologies, low power sensors and new and efficient wireless protocols will be further developed, security and privacy issues will be addressed, reducing power of wireless devices would be resolved. During the 2020s questions regarding large scale wireless networks, self adaptive services, cloud storage and algorithms for intelligent systems will be implemented and around 2025 and beyond, new autonomous IoT systems will be developed and will be able to perform independently and in mutual interaction, culminating with a plug and play smart IoT objects and things.

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# Entrepreneurship Education (EEd) at Bachelor Level in Developing Countries

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*Abstract*

*Entrepreneurship has been drawing attention of academia, business circles, policy makers and general public at an increasing rate as it is valued as an engine of economic developments. Although some argue that it can be learnt just by doing it, many types of EEd programs are being offered to high school students, university/college students and adults with various backgrounds and future plans. For efficient and effective EEd applications, various factors, such as local socio-economic conditions and degree of technological development in the country, need to be taken into consideration in tailoring EEd curricula and how to implement them. For example, EEd programs designed for developed countries need to be different from those for developing countries. This article focuses on EEd programs at higher education institutions in developing countries, for which entrepreneurship is a vital issue as it is one of the most effective tools for such countries to catch up with developed countries.*

**Keywords:** Entrepreneurship education, developing countries, higher education.

## 1. Introduction

One of the most valuable assets of a national economy is its entrepreneurs, who stimulate economic life by initiating and developing business ventures at the expense of taking risks of different sorts. Their undertakings create jobs and wealth as seen in many recent success stories of the brave and bright entrepreneurs. A part of the current crisis is attributed to the lack of entrepreneurial dynamism in modern, western, economies [1].

Contribution of entrepreneurship to economic growth differs for countries in different stages of economic development [2] and between countries according to GDP, and between regions an according to economic development level within countries [3, 4] as economic growth depend on local conditions at national and regional levels. Business creation and innovation are distinct determinants of national economic growth in developed countries [5]. For example entrepreneurial activity plays a more important role in some countries (e.g. the United States) than in others (Europe and Japan) because the rate of economic development is based on deviations from an 'equilibrium' rate of business ownership.

There seems to be a consensus on the value of entrepreneurship in the society however the question is how to transform individuals into entrepreneurs and how to equip entrepreneurs-to-be with the required knowledge and skills. These issues can be addressed by purpose-built education programs that can be delivered at various levels, namely high-school, university/college and adult education levels. Regardless of the level of the student, an EEd program should be able to deliver the following objectives:

- to provide the necessary technical and managerial knowledge & skills

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- to expose students to the real world as much as possible
- to motivate
- to increase awareness

This study compiles and describes important characteristics of an effective EEd programme at Bachelor level in developing countries.

## 2. Entrepreneurs, Entrepreneurship and Entrepreneurship Education

Entrepreneurs are people who have a business idea and brings all the necessary resources together so as to realize that business idea. In their endeavour, they take various types of risks. When they succeed, gains of the successful venture benefit many individuals and the whole society in many mays. Kirzner [6] stated that in economic development „the entrepreneur is to be seen as responding to opportunities rather than creating them; as capturing profit opportunities rather than generating them". Later, Gilder [7] considered that the entrepreneur is a superman who knows the hidden laws of economy and who contributes to progress. Also, he fights against poverty by creating new jobs. Other researchers adopted different approaches as follows:

Entrepreneurship is a concept with many dimensions and, consequently, there are various definitions of it. In order to be able to discuss the issue of entrepreneur education thoroughly, it would be useful to present a few of these definitions:

"Entrepreneurship is a purposeful activity to initiate, maintain and develop a profit oriented business." [8] "Entrepreneurship is the set of behaviours that initiates and manages the reallocation of economic resources and whose purpose is value creation through those means." [9] "Entrepreneurship is the resource, process and state of being through and in which individuals utilize positive opportunities in the market by creating and growing new business firms." [10]. "Entrepreneurship is a process that involves the discovery, evaluation, and exploitation of opportunities to introduce new products, services, processes, ways of organizing, or markets" [11]. Entrepreneurship is a creative human process, one which mobilizes resources from one level of productivity to another, a superior one. It implies the individual's will of taking on responsibilities and the mental ability of carrying out the task from idea to implementation. Another component of entrepreneurship consists in identifying opportunities where other people find only chaos, contradictions, or confusion.

As for entrepreneurship education, there are various approaches to the issue. As Hostager and Decker [12] stated general business management education seems to have no significant influence on entrepreneurial propensity that entrepreneurial education programs create. Some research showed that starting a business is related not only to education but also to tacit knowledge and individual abilities [13, 14]. On the other hand, all organizations and individuals that can perform initiative-taking, resource gathering, autonomy, and risk taking have the potential to be entrepreneurial [15], so education on these issues can enable the realization of this potential into business creation. As Drucker [16] also stated, entrepreneurship is risky hence it needs to be managed in a systematic approach for achieving these competencies. Hence he [17] saw entrepreneurship in terms of management methodologies and defined the entrepreneurship as a discipline and concluded that it can be learned as a discipline or methodology, in spite of the former beliefs on the nontransferable nature of entrepreneurship ability due to its totally tacit characteristics. However it is often observed that the entrepreneurs lack the methodological skills and rely on their perceptions and moods. These are the obstacles of firms that are in the early phases of their organizational life cycle that can also be called entrepreneur dominant period) on their way to institutionalization and growth that are needed for creating sustainable profitability, hence sustainable jobs and businesses. At this point, the education of entrepreneurs on business, management and administrative topics gains critical importance.

## 3. Entrepreneurship Education at Universities and Colleges

The interest of university graduates in entrepreneurship has traditionally been low [18]. The challenge of how to encourage young people to launch new firms that exploit their acquired skills as

well as academic research results, spinoffs, confronts academics and policy makers.
Infrastructure of entrepreneurship education has emerged in U.S. institutions of higher learning since an entrepreneurship course was first offered to Harvard MBA students in 1947 [19]. Since then, entrepreneurship began to take place in the agenda of business schools all over the world. Although entrepreneurship education is traditionally located in the business schools, engineering schools are also offering EEd programs as engineers themselves are the most suitable party in commercializing new technologies due to their extensive knowledge in technology. By equipping them with social, managerial and communicative skills, supported by relevant theoretical knowledge, engineering graduates can be turned into successful entrepreneurs. Entrepreneurship education in engineering schools have already become a popular issue [20, 21]. In recent years change appears to take place in technology intensive sectors where innovative new entrepreneurial endeavours disrupt industries and markets. A large part of this has been traced to the information and communications technology sector, which provides business opportunities for small innovative enterprises [22] (Karhunen, Ledyaeva, Gustafsson-Pesonen, Mochnikova, & Vasilenko, 2008).

It should be noted that, regardless of engineering or business school based, significant portion of entrepreneurship education is based on the context of formal education [23, 24] providing knowledge inputs required for entrepreneurship. It means that universities traditionally teach entrepreneurship as a subject, they share knowledge with students in the courses [25]. Education programs that are specifically designed for entrepreneurship with different content and teaching methods from traditional business courses [26] are needed. As Carlsson et al. [27] stated universities should entail actual opportunities for students to set up businesses and have to go beyond teaching and researching entrepreneurship and turn collaboration with industry into the catalyst for economic growth. But many initiatives in developed countries are increasingly becoming more action-oriented, emphasizing learning by doing [28]. In the U.S., academic institutions act as catalysts for start-ups [14]. However in developing countries entrepreneurship education is rarely sufficient even in teaching entrepreneurship in the traditional way [25].

Academic entrepreneurship (also referred to as university spinoffs or academic spinouts) is defined as new venture formation by faculty, staff or students who innovate in an academic or non-profit research context, and subsequently found a firm that directly exploits this knowledge [29]. Although technology transfer and university-firm relationships date back to the creation of land-grant universities and the Morrill Act of 1862, academic norms were strongly against both ownership and commercialization of technologies created for most of the post industrial revolution era [30, 31].

EEd at Bachelor level can be in the following forms [32]:

- Elective Minor program in entrepreneurship for all students.
- Bachelor program in Entrepreneurship or with a focus on Entrepreneurship.
- Extracurricular courses for interested students.

There are two types of entrepreneurship education models [33], out of which the university/college make its choice:

- the magnet model, where a single entity facilitates entrepreneurship classes for all departments
- the radiant model, where individual departments develop their own offers.

## 4. Conclusions

Designing an EEd program is a complex task, which involves addressing to meet various needs of an entrepreneur-to-be. In order to be able to develop an effective EEd program, first things first these needs must to be identified clearly. These needs can be outlined as follows (adopted from Smith, Schallenkamp and Eichholz [34]):

- **ICT Skills:**
  - Ability to use ICT to search, share and publish information
  - Interest in learning with computer based technologies
- **Managerial Skills:** Leadership, planning, organizing, supervising, directing, networking, Marketing/Sales, identifying customers, distribution

channels, supply chain management, managing financial resources, accounting, budgeting

- **Legal Skills:** establishing company, patent issues, privacy and security, employee-employer relations,

- **Personal Maturity Skills:**

  - **Self-Awareness:** ability to reflect and be introspective
  - **Accountability:** ability to take responsibility for resolving a problem
  - **Emotional:** ability to cope with a problem, tolerance for frustration

- **Technical Skills:** Operational skills necessary to produce the product or service related to issues of supplies/raw materials, office/Production Space, Equipment/Plant/Technology, logistics etc.

Because the discipline of entrepreneurship is still not as mature as the other disciplines of business as an academic topic and because it requires a well-defined and linked multidisciplinary approach, there still exists no common base and a agreed, successful model on how the entrepreneurship education should be [35]. But as Volkmann [36] pointed out, successful entrepreneurship education programs from various countries and regions are expected to serve to creation of an appropriate model for a global entrepreneurship education model. Raichaudhuri [37] introduced some basic required characteristics for creating an entrepreneurship education program that can create value:

- **The Theory-Practice Balance:** The primary requisite for an entrepreneurship course / program is to combine the rigours of academia while maintaining a reality-based focus and entrepreneurial climate in the learning experience. The challenge lies in balancing the abstracted general knowledge of academics with the specific knowledge and situational logic of practitioners. Since entrepreneurship combines the romance of new ideas with the reality of the business world, it is strongly recommended that the programme content be based on, and regularly modified by, a think-tank that includes both competent academics and practitioners.

- **Content**: Content design has to take into account the fact that entrepreneurial education requires integration of a variety of functional skills and knowledge instead of the functional specialist focus of standard management programs. Moreover, entrepreneurship education stresses the importance of the stage of development, an issue which is not dealt exclusively in conventional management programs. Therefore, courses and programs in entrepreneurship education have to illustrate early lifecycle challenges such as opportunity recognition; identifying and acquiring financial, human and technical resources; market entry; protecting intellectual property; legal requirements of new business, and strategic choices under resource constraints. Courses must also deal with subsequent development challenges including growth issues; new market development and expansion strategies; and institutionalizing innovation.

- **Skills**: In terms of skill inputs, entrepreneurial education must include courses in negotiation, leadership, creative thinking and ambiguity tolerance. It is also essential that students have exposure to the forefront of environmental changes, including technological developments, so as to identify emerging opportunities.

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# The validity of the scientific method in modern physics

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***Abstract***

*The scientific method is described clearly for the first time at Kitab al-Manazir (Book of Optics) of Ibn al-Haytham (Alhazen 965 – 1040). But recently there is some debate regarding its validity of theories describing our universe like string theory and multiverse. It is well known that scientific method paved the way for true science and technology through more than thousand years ago. We argue here that, scientific method should remain to be the only way to get and verify natural sciences.*

**Keywords:** scientific method, String theory, multiverse, Universe.

**Figure 1:** Alhazen (965-1040)

The feature associated with Alhazen's (Fig. 1) researches is related to systemic and methodological reliance on experimentation and controlled testing in his scientific inquiries. Furthermore, his experimental directives rested on combining classical physics with mathematics. This mathematical physical approach to experimental science supported most of his propositions in his famous book Kitab al-Manazir (The book of Optics) and grounded his theories of vision, light and color, as well as his research in catoptrics and dioptrics (the study of the refraction of light). [1] Bradley Steffens said in his book “Ibn Al-Haytham”: First Scientist has argued that Alhazen's approach to testing and experimentation made an important contribution to the scientific method.

It is worth mentioning that, the main motivation for Alhazen’s scientific method was absolutely religious; he thought that realizing the fact is an Islamic worship in itself, and regardless of the ability of the mind to think he must be mistaken, and that of ever protect science of error is the experiment. Alhazen is considered to be the "first true scientist" in the history based on his pioneering work on the scientific method [2].

As the scientific method commonly defined, this is the approach to investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge, based on the gathering of data through observation and measurement, followed by the formulation and testing of hypotheses to explain the data.

But the development and elaboration of rules for scientific reasoning and investigation has not been straightforward; scientific method has been the subject of intense and recurring debate throughout the history of science, and many eminent natural philosophers and scientists have argued for the primacy of one or another approach to establishing scientific knowledge.

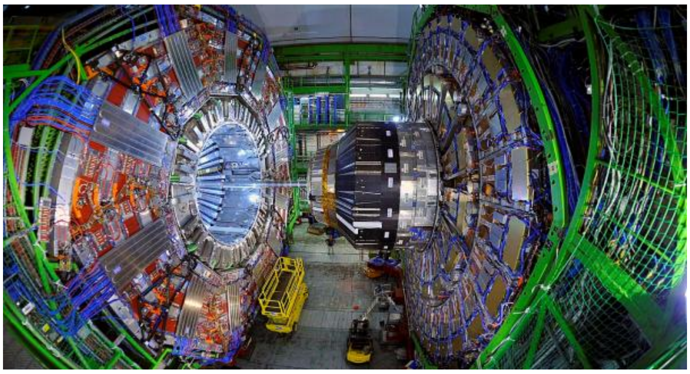

**Figure 2:** the Large Hadron Collider at CERN

Recent advances in elementary particle physics reached to the upper limit of the cost, and the technology in detection and discovery. In the other hand, we still have a lot of big mysteries without any clue. The most recent discovery of Higgs Boson (The Higgs boson is an

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elementary particle in the Standard Model of particle physics) was one of those issues. Despite being present everywhere, the existence of the Higgs field has been very difficult to confirm, because it is extremely hard to create excitations Because Higgs boson production in a particle collision is likely to be very rare (1 in 10 billion at the Large Hadron Collider LHC). The search for this elusive particle has taken more than 40 years and led to the construction of one of the world's most expensive and complex experimental facilities to date (With a budget of 7.5 billion euros), CERN's Large Hadron Collider LHC at Switzerland [3], able to create Higgs bosons and other particles for observation and study.

The LHC was built in collaboration with over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories [4]. It lies in a tunnel 27 kilometers (17 mi) in circumference, as deep as 175 meters (574 ft) beneath the Franco-Swiss border near Geneva, Switzerland. It is also the longest machine ever built. As of 2014, the LHC remains the largest and most complex experimental facility ever built [5]. By 2012 the LHC Computing Grid was the world's largest computing grid, comprising over 170 computing facilities in a worldwide network across 36 countries.

Spending billions of Euros or US dollars for constructing those gigantic machines like the LHC and VLHC will help answer some of the fundamental open questions in physics, concerning the basic laws governing the interactions and forces among the elementary objects, the deep structure of space and time, and in particular the interrelation between quantum mechanics and general relativity, where current theories and knowledge are unclear or break down altogether.

Although, we have many elegant theories concerning these issues but we still need the experimental verification for any of them. Experiments will protects us from the wrong perceptions. So, Data are necessary from high energy particle experiments to suggest which versions of current scientific models are more likely to be correct – in particular to choose between the Standard Model and Higgsless models and to validate their predictions and allow further theoretical development.

On 4 July 2012, the discovery of a new particle with a mass between 125 and 127 GeV/c2 was announced; physicists suspected that it was the Higgs boson [6-8]. By March 2013, after analysis of extremely huge amount of data, the particle had been proven to behave, interact and decay in many of the ways predicted by the Standard Model, and was also tentatively confirmed to have positive parity and zero spin [9], two fundamental attributes of a Higgs boson. There are many theoretical physicists still expected new physics beyond the Standard

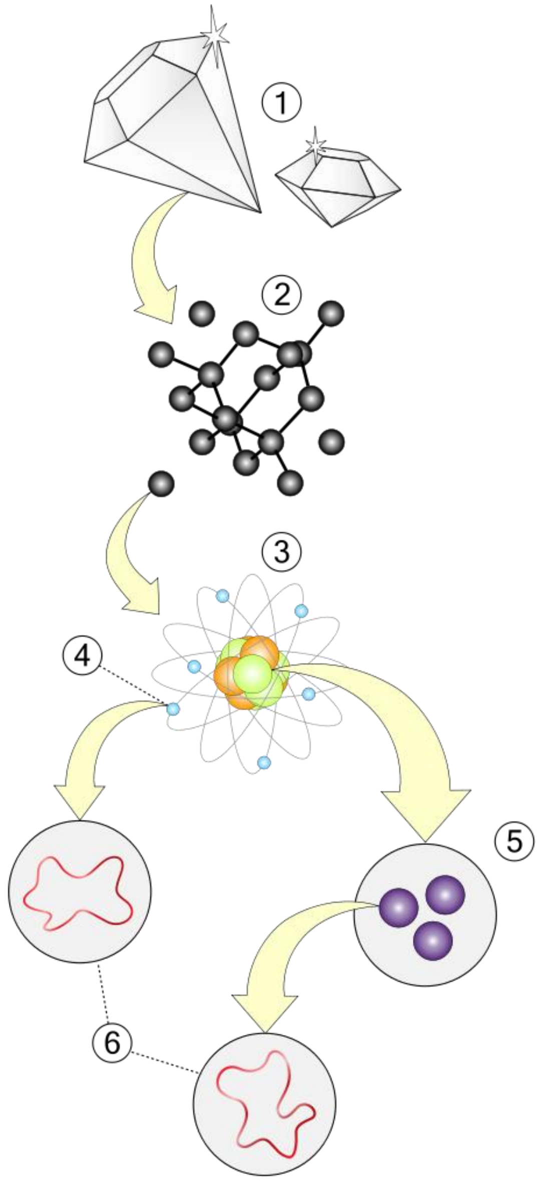


**Figure 3**: Different levels of magnification of matter, ending with the string level. 1. Matter, 2. Molecular structure (atoms), 3. Atom (protons, neutrons, electrons), 4. Electron, 5. Quarks, 6. Strings. [10]

Model to emerge at the TeV energy level, as the Standard Model appears to be unsatisfactory.

Indeed, it is a very long and costly process to verify something experimentally related to the structure of the universe. Therefore, debates in some physics groups took a distressing turn. Confronted with difficulties in applying fundamental theories to the observed Universe, some researchers called for a change in how theoretical physics is done. They began to argue — explicitly — that if a theory is sufficiently elegant and explanatory, it need not be tested experimentally, contravention with centuries of basic tradition of defining scientific knowledge as empirical.

We discuss here our opinion that totally complies with the necessity of the scientific method as the only way for the true science. As Alhazen and Karl Popper-the philosopher of science- said: a theory must be falsifiable to be scientific.

These upcoming ideas are circulating by two distincted groups, String theory and cosmology theorists. These unprovable hypotheses of string theory and multiverse are completely different from those that relate directly to the reality and that are testable through observations by using the most recent technology — such as the standard model of particle physics and the existence of dark matter.

**STRING THEORY**

Some string theorists claim to bypass the theory from any experimental verification. They believe that it must include one face of truth even though it relies on extra dimensions that we can never observe. No doubt that string theory is an elegant theoretical framework in which the point-like particles of particle physics are replaced by strings (one-dimensional space entities) and membranes (higher-dimensional extensions) existing in higher-dimensional spaces [11]. These strings could explain all types of observed elementary particles using quantum states of these strings. But the higher dimensions are wound so tightly that they are too small to observe at energies accessible through collisions in any practicable future particle detector. In addition to the particles postulated by the standard model of particle physics, string theory naturally incorporates gravity and so is a candidate for a theory of everything, a self-contained mathematical model that describes all fundamental forces and forms of matter. String theory is supposedly the only source of knowledge available that capable of unifying the four fundamental forces. Besides this prospective role, string theory is now widely used as a theoretical tool and has shed light on many aspects of quantum field theory and quantum gravity [12].

Although a great deal of recent work of using string theory to construct realistic models of particle physics, several major difficulties complicate efforts to test models based on string theory. The most significant is the extremely small size of the Planck length, which is expected to be close to the string length (the characteristic size of a string, where strings become easily distinguishable from particles). Another issue is the huge number of meta-stable vacua of string theory, which might be sufficiently diverse to accommodate almost any phenomena we might observe at lower energies. Richard Feynman [13, 14], Roger Penrose [15] and Sheldon Lee Glashow [16], have recognized and criticized string theory for not providing novel experimental predictions at accessible energy scales. Some scientists went far than this by saying that it is a failure as a theory of everything. On the other hand, many theoretical physicists, including Stephen Hawking, Edward Witten and Juan Maldacena, believe that string theory is a step towards the correct fundamental description of nature: it accommodates a consistent combination of quantum field theory and general relativity, agrees with insights in quantum gravity and has passed many non-trivial checks of its internal consistency.

In principle, some aspects of string theory can be tested experimentally. For example, a hypothesized symmetry between fermions and bosons central to string theory — supersymmetry — predicts that each kind of particle has an as-yet-unseen partner. No such partners have yet been detected by the LHC, restricting the range of energies at which supersymmetry might exist. If these partners continue to elude detection, then we may never know whether they exist. Proponents could always claim that the particles' masses are higher than the energies probed.

By Mentioning Bayesian analysis (a statistical method for inferring the likelihood that an explanation fits a set of facts), Theorist and philosopher Richard Dawid [18] argues that the veracity of string theory can be established through philosophical and probabilistic arguments about the research process. But that increase of probability can be purely theoretical. Because "no-one has found a good alternative" and "theories without alternatives tended to be viable in the past", he reasons that string theory should be taken to be valid.

Actually, this reminds us with the dilemma of Luminiferous aether and how many scientists and philosophers tried by different means to validate the idea philosophically after many experimental failure. Instead of belief in a scientific theory increasing when observational evidence arises to support it, he suggests that theoretical discoveries bolster belief. History of science proved that conclusions arising logically from mathematics need not apply to the real world. There are many experiments have proved many beautiful and simple theories wrong, from the steady-state theory of cosmology to the SU 5 Grand Unified Theory of particle physics, which aimed to unify the electroweak force and the strong force. Inductivism was overturned by Popper and other twentieth-century philosophers.

We cannot ensure that there are no alternative theories in the future. We may not have the appropriate technology to found them yet. Or the hypothesis might be wrong.

**Multiverse**

The cosmologists group, too, are seeking to abandon experimental verification of grand hypotheses that invoke imperceptible domains such as the multiverse, the 'many worlds' version of quantum reality (in which observations spawn parallel branches of reality) and pre-Big Bang concepts [19].

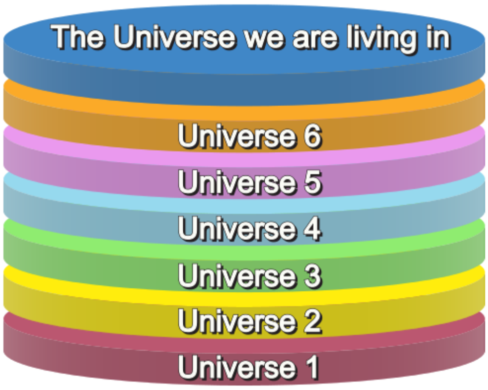


**Figure 4:** "Bubble universes": every disk is a bubble universe (Universe 1 to Universe 6 are different bubbles; they have physical constants that are different from our universe); our universe is just one of the bubbles. [20]

The term 'multiverse' was coined in 1895 by the American philosopher and psychologist William James in a different context [21]. The scientific (Fig. 4) hypothesis for the multiverse is the set of infinite or finite possible universes (including the universe we consistently experience) that together comprise everything that exists: the entirety of space, time, matter, and energy as well as the physical laws and constants that describe them. The various universes within the multiverse are sometimes called parallel universes or "alternate universes". The structure of the multiverse, the nature of each universe within it and the relationships among the various constituent universes, depend on the specific multiverse hypothesis considered.

The idea of multiverse is motivated by an enigma: why fundamental constants of nature, such as the fine-structure constant that characterizes the strength of electromagnetic interactions between particles and the cosmological constant associated with the acceleration of the expansion of the Universe, have values that lie in the small range that allows life to exist.

There are deep debates within the physics community concerning the multiverse hypothesis. Physicists disagree about whether the multiverse exists, and whether the multiverse is a proper subject of scientific inquiry [22]. Basically, the multiverse explanation relies on string theory, which is as yet unverified, and on speculative mechanisms for realizing different physics in different sister universes. It is not, in our opinion, robust, let alone testable.

We can find supporters for one of the multiverse hypotheses from the big names in theoretical physics like Stephen Hawking [23], Steven Weinberg [24], Brian Greene [25, 26], Max Tegmark [27], Alan Guth [28], Andrei Linde [29], Michio Kaku [30], David Deutsch [31], Leonard Susskind [32], Raj Pathria [33], Sean Carroll, Alex Vilenkin [34], Laura Mersini-Houghton [35, 36], and Neil deGrasse Tyson [37]. In contrast, critics such as Jim Baggott [38], David Gross [39], Paul Steinhardt [40], George Ellis [41, 42] and Paul Davies have argued that the multiverse question is philosophical rather than scientific, that the multiverse cannot be a scientific question because it lacks falsifiability, or even that the multiverse hypothesis is harmful or pseudoscientific.

We are “authors” support the critics for the idea of the multiverse as long as we do not have experimental evidence. There is a lot of illogic situations come from that idea and till now, we do not have even a philosophical interpretation. Simply because according to that idea there are Billions of universes — and of galaxies and copies of each of us — accumulate with no possibility of communication between them or of testing their reality.

Accepting the string theory and multiverse without experimental verification will not only mislead the integrity of physics but also will destructively affect the naturalized epistemology. This collection of philosophic views concerned with the theory of knowledge that emphasize the role of natural scientific methods as the main objective of naturalized epistemology will be missed and without meaning. This shared emphasis on scientific methods of studying knowledge shifts focus to the empirical processes of knowledge acquisition and away from many traditional philosophic questions. There are noteworthy distinctions within naturalized epistemology.

Substitution of the naturalism maintains that traditional epistemology should be abandoned and replaced with the methodologies of the natural sciences which coined in the scientific method. The general thesis of cooperative naturalism is that traditional epistemology can benefit in its inquiry by using the knowledge we have gained from the cognitive sciences.

We believe that, the consequences of over-claiming the significance of certain theories are insightful — the scientific method is at hazard. To state that a theory is so good that its existence supplants the need for data and testing in our opinion risks misleading students and the public as to how science should be done and could open the door for pseudoscientists to claim that their ideas meet similar requirements. The scientific research will turn to be science fiction.

In order to find a solution for this issue, we should look at the history of science. How many problems like this happened before? No one can predict the future of the physics. No one can block the way in front of revolutional ideas that may open a completely new era of physics and this happened many times before.

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# Science and Technology Parks and University Collaborations

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***Abstract***

*Science and technology parks (STP) are seen as a catalyzer for the economic and industrial development for developing countries. For future STPs , it's needed to determine from beginning to last version of them, their properties, similar and different structures, regional priorities, expectations and etc. This study will demonstrate to create a new science and technology parks, what the potential advantages and disadvantages are and what the factors should be taken account, etc. as a compiling review.*

*The success of the STPs close related to University collaborations. Universities are supporting the STP firms as researchers and laboratories. University based STPs have much more benefits for researches and innovations, incubation activities, start-up/spin off firms and entrepreneurship opportunities.*

**Keywords:** Science and Technology Parks, Incubation Centers, University Research Centers.

## 1. Introduction

Science and Technology Parks (STP)have been in existence in the United States since at least the early 1950's.Silicon Valley was a pioneer in the development of STPs the world. Originally known as Stanford University Science Park and have since spread around the world, with new technology parks continually arising. Originally, the term "technology park" had a very limited definition, focusing on the real estate aspect of the park concept, in which universities typically leased real estate, office space or research facilities to businesses. Sometimes these arrangements are referred to as "industrial estates"or "firm hotels." The term, however, has evolved to include a much broader range of functions, including economic development and technology transfer.

The official definition by the International Association of Science Parks (IASP); A science park is an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities. IASP's definition also goes on to say that the expression "science park" may be replaced in this definition by the expressions "technology park", "technopole" or "research park".[1].

## 2. Objective and Methods

Aim of this study is to find a path way while establishing new generation STPs with demonstrating the overall STPs, their structures and expectations from them. The literatures on science and technology parks have been reviewed.

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Statistics about STPs, different approaches for development, university, institute, research centers, incubation centersand industryand/or business relations have been analyzed. And their effects on science and technology parks criticized. The main benefits of STPs on regional and economic developments, entrepreneurial and new firm creations have been demonstrated.

STPs allover the world in numbers [2]:

- The number of technoparksallover the world is over 4000. (including incubation centers)
- The second half of the eighties was the period where most technoparks were launched. (23.38 %)
- 83% are non-profit organizations. 88% has an incubation unit in its structure; 70% was established by the public investment and 73% launches out by the land rent.
- 26% of companies in technoparks are active in ICT sector; 20% is in biotechnology; 19% is in electronics; 8 % is in environment technologies, 6% is in advanced materials; 5 % is in chemistry; 9 % is in agriculture and 7 % is in other sectors.
- 51% of technopark companies are defined as the service companies, 18% is as industrial companies and 26% is as R&D companies.
- 89% of technopark companies are SMEs. (according to the EU standards)

According to International Association of Science Parks-IASP, it's seen the Science and Technology Parkselements on Fig. 1 [3].

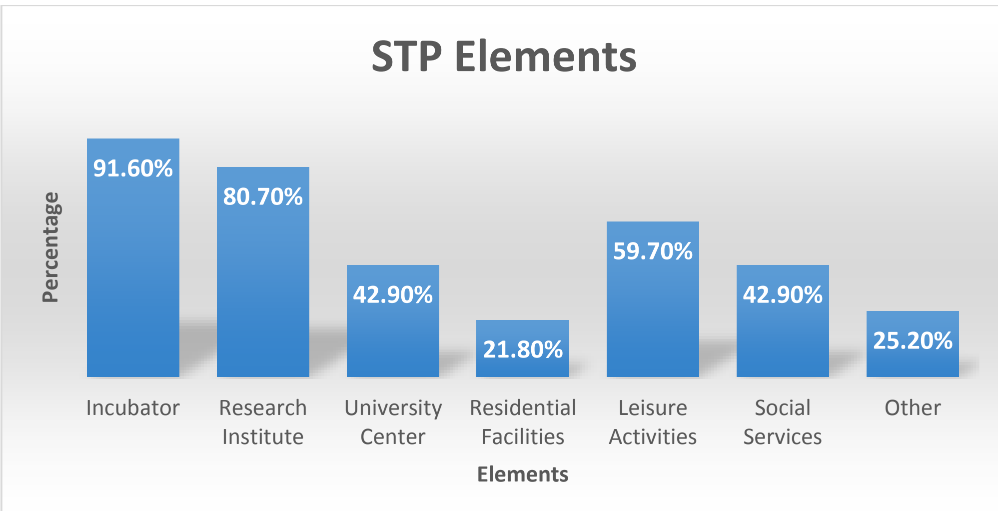


*Figure 1. STP Elements*

Business incubators (present in 91.6% of STPs) and research centers (present in 80.7% of STPs) are two of the most common building blocks in Parks around the world.

The STPs are divided three categories as their specializations. Specialists STPs concentrate on one or very few technology sectors. Semi-specialists are parks with a clear emphasis on one or very few technology sectors yet have companies and institutions from other sectors. Generalists do not have a clear preference in the types of technology that they work with. Regardless of the degree of specialization, all Parks have entry requisites in order to select which companies may locate in the Park[3]. Generalist STPs are more common, but for the new generation STPs, the specialist ones are more valuable.

## 3. Results and Discussion

Science and technology parks mostly related to universities or research institutes, for researchers and academician based. One of the main effective factors of potential opportunities for STP is collaborations to universities and institutes.

Science parks are often seen as, or are hoped to be, the solution to complex political and economic issues in society, for example regional industry problems [4], the under-commercialization of publicly financed research[5], a shortage of new product development, and unemployment.

At the core of the expectation from science and technology parks is a catalyst to economic growth through its contribution to innovation and further development of high-tech firms. In the 1980s and 1990s, this belief was fuelled by the explosive growth and value creation in high-tech industries such as information technology (IT), communication technologies and biotechnology [6].

Science parks serve many masters with different interests and expectations. Universities expect science parks to enable them to commercialize their researchideas and secure funding for further research. Entrepreneurs and smaller high-tech companies want high quality prestigious accommodation, a close association with the university, other similar businesses on site and the managerial services provided by the park staff [7].

### 3.1. Science and technology parks and university / institute relations

The location of science and technology parks is essential that being closer to universities or institutes.The location of STP is proximal to important customers, suppliers, researchers and other businesses/ organizations, and the NTBFs will be able to build networks that support their development. In different universities certain institutes or departments strongly relates to industry. Most accessing of academic resources relates to contacts based on recruiting university graduates or informal contacts. In different universities certain institutes or departments strongly relates to industry. The research links is possible only at the level ofthe firm involved[8]. There are two principal forms of academic-Science Park links at the level of the individual Park NTBF:

- The establishment of spin-off firms, formed by academic staff taking research out of the laboratory and onto the Science Park, starting their own commercial firms

- The occurrence of research links facilitating technology and knowledge transfers.

Research links may take many forms, from formal contracts for research to more informal contracts as well as the transfer of personnel between academia and industry [8]. The linkage between Science Park NTBFs and the university is fundamental to the concept of Science Parks. The universities and the smaller-firm sector have always played a part in economic progress. It is only in recent times that their roles were seen to overlap one another, most notably in the establishment of Science Parks. If small firms were shown to be more innovative than large firms, there would be some case for considering policies to promote their development. NTBFs are of key interest[9]:

- They are thought to embody the technologies of the future and hence provide secure employment opportunities for several generations.

- In the United States NTBFs have exhibited spectacular rates of employment growth

‘Science Park Village’ can be divided up on two parallel existing norms that causes building of networks. The first one were related to the academy, and the second were related to integration and acceptance how to conduct business[10]. The co-operation between firms were less than one might expect [11]. It was argued that the reason for location in a Science Park was not to establish new contacts but to preserve old ones. The lack of cooperation and networking is due to heterogeneity of the located firms[12]. Because of the different structures there is no basis for co-operation, hence there is a need for a ‘critical mass’ to develop.

The STSs reflect an assumption that technological innovation stems from scientific research and that STPs can provide the catalytic incubator environment for the transformation of ‘pure’ research into production[13]. NTBFs working with universities that are more proximity may achieve certain advantages. Proximity between firms and universities promote the natural exchange of ideas through both formal and informal networks [14]. The formal methods include licensing and cooperative alliances, while informal methods include mobility of scientists and engineers, social meetings and discussions [14-16]. Second, formal and informal exchanges provide information not only regarding formal projects, but also about on-going research among other firms and organizations. The key relationship is between the university and the NTBF and include the proximity between the firm and its university(Fig. 2)[17].

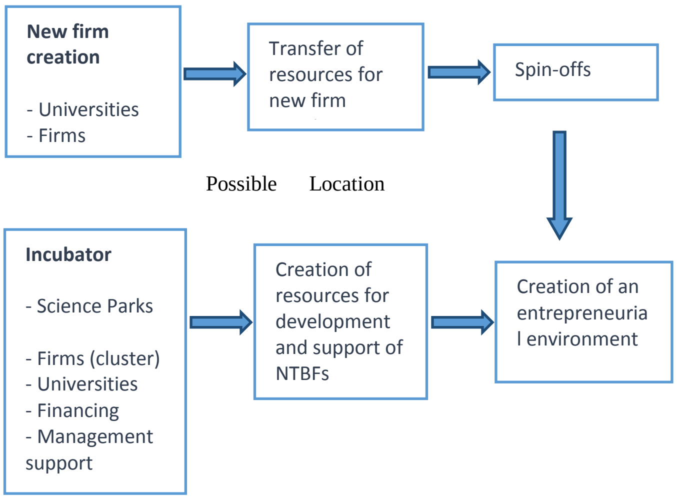


*Fig. 2. STPs and the creation of an entrepreneurial environment*

Universities and other higher education institutions are an important source of new scientific knowledge. Industry can gain access to this knowledge or resources by developing formal and informal links with higher education institutes[18]. Therefore, the development of higher education institute links is assumed to encourage technology innovation and production[19]. Hence locales with highly interlinked higher education institutes are expected to have enhanced levels of wealth creation and job generation [20].

### 3.2. Incubators

The framework of technology incubators in the science parks have been identified and incorporated in the assessment framework: advantages from pooling resources, sharing resources, consulting services, positive effect from higher public image, networking advantages, clustering effect, geographic proximity, cost subsidies and funding support.

The benefits required by technology founders at different stages of development are varied and therefore, the general merits that are claimed by incubators as useful to technology start-ups are debatable. To meet the needs of technology firms during their stages of development, it is recommended that incubators' services and support should be prioritized in accordance with the development process of the technology firms. It's seen the companies being incubated within the science and technology parks in the world (Fig. 3).

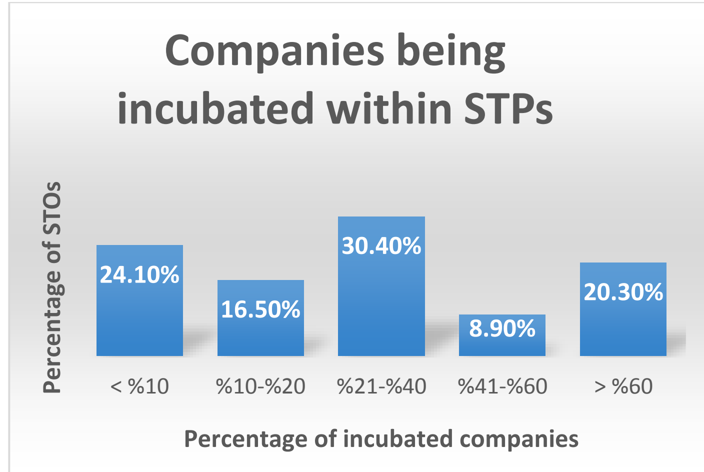


*Figure 3. Companies being incubated within STPs*

Incubation is important: in 30.4% of STPs incubates represent between 21% and 40% of resident companies.

One of the objectives of establishing the science park in most countries is to provide an infrastructure of technical, logistic and administrative support that a young firm needs in the process of struggling to gain a foothold in a competitive market [21]. It is particularly important to those industrialized economies whereby small high tech firms are encouraged in their start up stage. Therefore, most science parks would accommodate incubator programs leading to the development of technology based firms. It is also widely believed that business incubator can provide a nurturing environment for new business start-up and therefore, leading to later development of growth-oriented firms [22].

The role of science parks is to provide the 'catalytic incubator environment' needed to transform basic science at universities into commercially viable innovations [14]. The different definitions of science parks concur that the property dimension is a key factor. According to the UK Science Park Association's definition a science park is a property-based activity configured around the following[6]:

† formal operational links with a university or other higher educational or research institution,

† the formation and growth of knowledge-based business and other organizations normally resident on site,

† a management function which is actively engaged in the transfer of technology and business skills to the organizations on site.

## 4. Conclusions

The structure and location of the science and technology parks are playing important role on their growth and on regional development economical expectations etc. The collaboration of science and technology parksto university, industry and other stakeholders can effect to achievement of STPs. The spin off companies, new technologies and ideas from incubation centers, and academic supports to the industries, and also academician firms and collaboration them to angel investors'cause to create and improve to the new generation science and technology parks.

The existing university research centers should switch themselves to the new generation STPs to be successful and provide the expectations from them.

While creation of a new STP, it should be analyzed to all regional opportunities and difficulties. After that, the structure can be designed based on local advantages which can effect to their specialization. It can be created and specialists science park or generalist science park depend on the expectations and regional advantages.

For creation and actuation a STP, the necessitiesar[23];

Stake holders; regional and national governmental organizations, universities and institutions, industry and business sector collaborations, which they should apperceive the role of STPs, have well network each other.

Clusters; based on regional and industrial advantages.

Specialization; based on regional advantages.

Academicians and researchers; human source to create new technology and ideas.

Close relation to universities and institutes; for supervising, source of the staff and laboratories.

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# Signal Perception and Transduction in Plants

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***Abstract***

*Plants are sessile organisms and are not able to move away from adverse environmental conditions and must response to an array of environmental and developmental cues. They heavily rely on high sensitivity detection and adaptation mechanisms to environmental perturbations. Signal transduction, the means whereby cells construct response to a signal, is a recently defined focus of research in plant biology. Over the past decade our understanding of plant signaling pathways has increased greatly, in part due to the use of molecular genetics and biochemical tools in model plants for example Arabidopsis thaliana and Medicago truncatula. This has assisted us in the identification of components of many signal transduction pathways in diverse physiological systems for example hormonal, developmental and environmental signal transduction pathways and cross-talk between them.During the last 15 years the number of known plant hormones has grown from five to at least ten. Furthermore, many of the proteins involved in plant hormone signaling pathways have been identified, including receptors for many of the major hormones. In addition, recent studies confirm that hormone signaling is integrated at several levels during plant growth and development.*

*In this review paper we have covered recent work in signaling pathway in plants especially how plants sense biotic and abiotic stresses and the potential mechanisms by which different chemical molecules and their downstream signaling components modulates stress tolerance.*

**Keywords:** Plant signaling, plant hormones, phytochrome signaling, receptor kinases, G protein coupled receptors

## 1. Introduction

The signaling networks that have evolved to generate appropriate cellular responses are varied and are normally composed of elements that include a sequence of receptors, non-protein messengers, enzymes and transcription factors. Receptors are normally highly specific for the physiological stimulus, and therefore are disparate in their identities. Likewise enzymes and transcription factors tend toward specificity, and this fact is reflected in abundance at the genome level. The Arabidopsis genome, for example, potentially encodes in the region of 1000 protein kinases, 300 protein phosphatases, and 1500 transcription factors [1-3]. By contrast, non-protein messengers are relatively few. They include calcium [4], nucleotides [5], hydrogen ions [6], active oxygen species and lipids [7, 8]. Among stimuli- both external and internal- that convey information to plants are light, mineral nutrients, organic metabolites, gravity, water status, turgor, soil quality, mechanical tensions, wind, heat, cold, freezing, growth regulators and hormones, pH, gases ($CO_2$, $O_2$ and $C_2H_4$), wounding and diseases, and electrical flux.

Plant responses to stimulus are modulated by developmental age, previous environmental experience, and internal clocks that specify the time of year and the time of day. For mature plant cells, the response can be physiological and biochemical; for growing cells, it can be morphological and developmental. Integration of various forms of signaling information is usually crucial to determining the final response. In a seed, for example, the decision to germinate can be irreversible and, if timed inappropriately, could be fatal. This clearly reflects the presence of complex system for signal recognition and transduction in this germination process.

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## 2. Over view of Signal transduction

The signal transduction pathway uses a network of interactions within cells, among cells, and throughout plant[9]. The external signals that affect plant growth and development include many aspects of the plant's physical, chemical, and biological environments. Some external signals come from other plants. Apart from gravitropic signals, all other signals vary in intensity, often from minute to minute [10]. Many signals interact cooperatively and synergistically with each other to produce the final response. Signal combinations that induce such complex plant responses include red and blue light, gravity and light, growth regulators and mineral nutrients [11].

For example the overall regulation of seed germination involves control by both external factors and internal signals. The involvement of gibberellin acid in the initiation of seed germination is well known [12]. Peptides and lipo-chitooligosaccharides are another class of signaling molecule that is currently attracting considerable interest and generating much excitement [13], [14]. The emerging information is the peptides are ubiquitous signaling molecules in plants, and that they appear to operate via receptor serine/threonine kinases. With more than 340 genes in the Arabidopsis genome encoding putative proteins in this class, it is likely that more peptide-based signaling systems will be identified in plants in the near future. Lipo-chitooligosaccharides [15] produced by rhizobia are a class of signaling molecules that mediate recognition and nodule organogenesis in the legume-rhizobia symbiosis. Their synthesis is specified by the nodulation genes of rhizobia and hence they are commonly known as Nod factors. Studies using plant and rhizobial mutants and purified molecules suggest that Nod factors are recognized by more than one receptor. Genetic approaches have been initiated to identify specific genes involved in Nod factor signal perception and transduction [16]. The major advance in our understanding of LCO perception requires the cloning of genes encoding Nod factor receptors. Genetic and biochemical approaches appear to be the most promising strategies. All of the signal mentioned above including hydrogen peroxide and nitric oxide mediated signaling is believed to operate at or near the plasma membrane. The extracellular matrix (ECM), which was once mistakenly thought to be inert as far as signal transduction was concerned, is also a very important repository of signaling information in plants [17, 18]. The possibility that plants might signal through heterotrimeric G proteins and small G proteins has also created much excitement since their discovery in yeast and animal systems [19],[9]. Over the years, a considerable body of evidence has amassed by studies involving pharmacological intervention that suggests that these proteins are involved in numerous signaling pathways in plants. Phospholipase D is a possible targets for G proteins in plants [20-22] and emerging as one of the important components of cellular signaling in plant cells. Other intracellular signaling components, which are certainly involved in cross-talk/signal integration, are the mitogen-activated protein (MAP) kinases (MAP-kinase module). The emerging story of MAP kinase reveals a highly flexible signaling module that is involved in a large number of signaling pathways. Plant hormones are other small organic signaling molecules which can influence so many aspects of growth and development. The concept of cross-talk between hormones has attracted much attention, with the idea that hormone signaling pathways make up a complex interacting web of informational transfer that allows a variety of stimuli to cause a plethora of overlapping responses [23].

RNA-mediated regulation of genes responsible for signaling in plants is also a recent and exciting discovery. A decade ago, the existence of a double-stranded RNA (dsRNA)-directed RNA degradation and DNA methylation mechanism was discovered in plants and animals, and identified as defense system against viruses and transposons. It now seems that components of this mechanism not only generate short interfering RNAs (siRNAs) that direct the defense system, but also short temporal RNAs (stRNAs) or microRNAs (miRNAs), from endogenous, developmentally expressed, partially self-complementary RNA transcripts [24],[25]. The stRNAs regulate the expression of target genes by inhibiting the translation of their mRNAs, and large numbers of miRNAs are being found in a wide range of organisms. The discovery of miRNAs probably heralds the start of investigations into a very important, but previously unsuspected, part of gene regulation in signal transduction. Another part of gene regulation in signal transduction is through RNA binding proteins which affect RNA stability and controls the translational initiation [26][27]. RNA binding proteins are involved at all stages in the life of an RNA molecule, from transcription through to degradation, and are central to the cell's maintenance and development.

## 3. Signals from the Environment

Numerous environmental factors influence plant development. Temperature, light, touch, water, and gravity are among the stimuli that serve as signals for the activation of endogenous developmental programs. Of these, light has an especially important role, not only as an energy source for photosynthesis, but also as a stimulus for many developmental processes throughout the life cycle of plants, from seed germination through flowering. In plants, light-dependent responses are controlled by a series of photoreceptors that can be classified into three known groups-the phytochromes, cryptochromes and phototropins [28-30]. Phytochromes are red-light/far-red-light (R/FR) photoreceptors that perceive light through a tetrapyrrole chromophore that is bound covalently to their amino-terminal photo sensory domain. The carboxy-terminal domain contains two PAS (for period circadian protein, Ah receptor nuclear translocator protein and single-minded protein) repeats, which initiate a signaling cascade by mediating direct interactions with molecules such as the basic-helix-loop-helix transcription factor PIF3, and a histidine-kinase-related domain (HKRD), which might phosphorylate direct targets such as phytochrome kinase substrate 1 (a protein that negatively regulates phytochrome signaling. The light-labile phytochrome (phy)A is more active in far-red light (FR), whereas phyB and other light-stable phytochromes are more active in red light (R). Light stability of these phytochromes depends on their specific properties which regulates There are several properties of phytochromes which affects the differential response of these phytochromes.This difference is due in part to their differential light-stability, but also to other properties that are specific to the phyA domain (see Fig1, [31]).

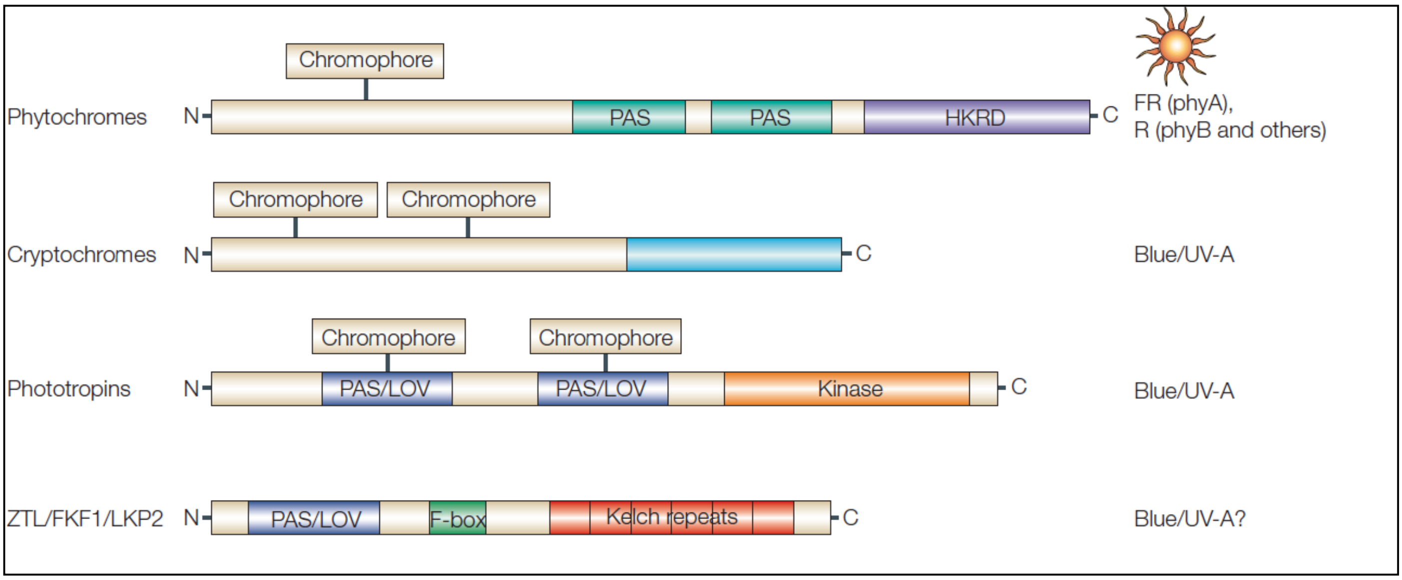


*Figure 1. The plant photoreceptors involved in signal transduction.*

Cryptochromes are blue/UV-A photoreceptors that bind pterin (5,10-methenyltetrahydropteroyl polygultamate) and flavin chromophores at their amino-terminal domain. Blue-light activation of cryptochromes initiates a signalling cascade through their carboxy-terminal domain. This signaling cascade operates in part through the direct inactivation of constitutive photomorphogenic 1 (COP1), which is a general repressor of photomorphogenic responses [30]. Phototropins have two PAS/LOV domains that bind a flavin mononucleotide (FMN) chromophore. The absorption of blue light triggers the formation of covalent adducts between FMN and cysteine residues in the PAS/LOV domains, which induce a conformational change that is thought to initiate a signalling cascade through activation of the serine/threonine kinase activity at the carboxy-terminal domain [30].Zeitlupe (ZTL), flavin-binding kelch repeat F-box 1 (FKF1) and LOV kelch protein 2 (LKP2) share a unique combination of motifs, which includes an amino-terminal PAS/LOV domain, an F-box domain that probably recruits proteins for ubiquitylation and subsequent degradation, and six kelch repeats that mediate protein–protein interactions [32],[33],[34],[35]. The PAS/LOV domain of this family of proteins might bind FMN, allowing these molecules to target specific proteins for degradation in a light-dependent manner [30].

Phytochromes are typically encoded by small multigene families,e,g. PHYA-PHYE in Arabidopsis [36]Quail 2002 a, b). Each forms a homodimer of ~ 240 kDa and light sensitivity is conferred by the presence of a tetrapyrrole chromophore covalently bound to the N-terminal half of each monomer ((Montgomery, 2002 #208)Montgomery and Lagarias, 2002). Dimerization domains are located within the C-terminal half of the proteins, as are other domains involved in the activation of signal transduction [37]Quail 2002a). Each phytochrome can exit in two photoinconvertable confirmations, denoted Pr (a red light-absorbing form) and Pfr (a far red light-absorbing form). Because sunlight is enriched in red light (compared with far red light), phytochrome is predominantly in the Pfr form in the light, and this can convert back to the Pr form during periods of darkness by a process known as dark reversion. Photo conversion back to Pfr can also be mediated by pulses of far red light.

The primary mechanism of phytochrome regulation of gene expression centre on two strikingly different hypotheses (Fig. 2). In one, it is considered to be a kinase that act on multiple substrates thereby regulating the expression of genes differentially. The other is that phytochromes interacts with one or more specific reaction partners that direct signal transduction towards the selective control of gene expression (Fig 2) [37].

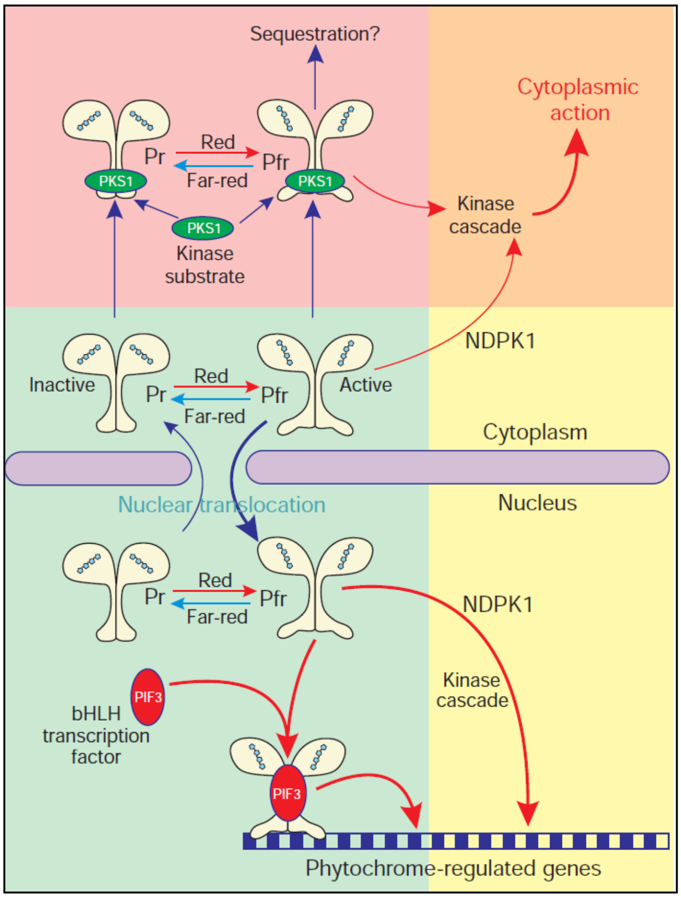


*Fig 2. Diagram shows the phytochrome action and the mechanism of phytochrome mediated gene regulation.*

Phytochromes undergo photoconversionfrom the biologically inactive form (Pr) to the active form (Pfr). Pr and Pfr are shown asdimers in the cell. The Pr–Pfr conversions are initiated by photon absorption in thechromophore leading to steric changes, causing the holoprotein to `open up' andfacilitating interaction with putative reaction partners. The Fig 2 shows the threemajor theories for the subsequent actions of the phytochromes, although Pfr mayregulate growth and development by other processes. Pink area: both Pr and Pfrinteract with PKS1, the phytochrome kinase substrate, in the cytosol. This may be thefirst step in a kinase cascade (orange area) culminating in action within the cytoplasm. Alternatively, interaction with PKS1 may result in sequestration ofphytochrome in the cytosol, preventing translocation to the nucleus. Yellow area: Pfr interacts with NDPK1, a nucleoside diphosphate kinase, which is located both in thecytoplasm and the nucleus. Again, this interaction may initiate a kinase cascade(orange) leading to ultimate action within the cytoplasm and/or nucleus. Green area:Pfr translocates to the nucleus and Pr is translocated back to the cytoplasm. Theweights of the arrow emphasize the differential rates of import and export. Within thenucleus, Pfr binds with PIF3 (phytochrome interacting factor 3) which is locatedexclusively within the nucleus. PIF3 is a basic helix–loop–helix transcription factorthat binds to the promoters of selected light-regulated genes in combination with Pfr and initiates or enhances transcription.In principle, the gene expression and regulationcould emanate from the kinase activity of phytochrome *per se*, and/or activation of NDPK1 [38].

Phytochrome localization to the nucleus is highly significant finding given that many phytochrome responses are dependent upon changes in gene expression. However, it should be noted that phytochrome translocation is rather slow, except for phyA, and that the majority of the intracellular Prf pool is not translocated to the nucleus [39]. These and other observations suggest that phytochromes may activate signaling pathways in both the cytoplasm and the nucleus. Using phyB truncated protein for localization studies have shown that the carboxy- terminal domain of phyB localizes to discrete sub nuclear foci even in the dark, whereas the amino-terminal domain remains mostly in the cytoplasm [11].

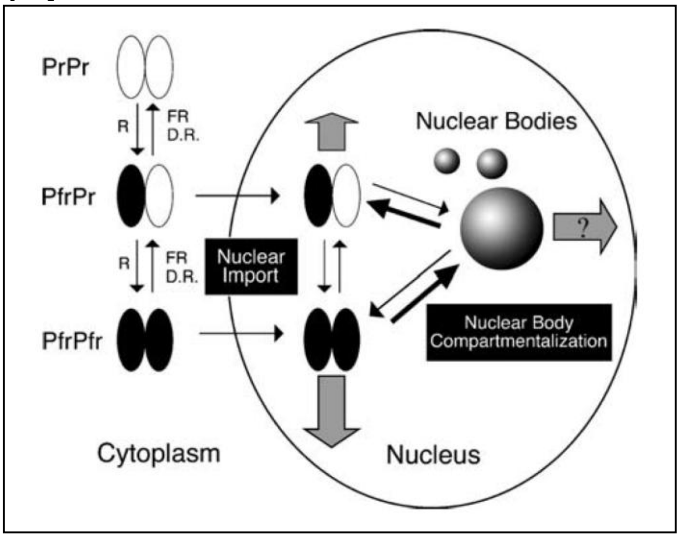


*Fig 3. A schematic illustration shows the localization of phytochrome using phyB as a model [11].*
*Translocation of phytochromes after light activation has been shown in two steps. Nuclear import and localization in nuclear bodies.At least one molecule of phytochrome in the Pfr form(phytochrome dimer) is required for nuclear import. In the nucleus, PfrPfrhomodimers are more likely to compartmentalize to nuclear bodies. Shaded arrowsrepresent phyB signaling function. D.R., dark reversion.*

Genetic approaches have implicated a range of nuclear-localized proteins downstream of phytochrome and its physically-interacting partners that are involved in phytochrome signaling. Some of these are now quite well characterized, most notably the COP9 signalosome, COP1, and HY5 [40]. The COP1 and COP10 proteins are not intrinsically associated with the COP9 signalosome but also appear to play a role in regulating protein degradation[41-43]. COP10 resembles a ubiquitin-conjugating E2 enzymes [42-44], whereas COP1 has been proposed to be an E3 ubiquitin ligase containing several recognizable domains, such as RING-finger zinc-binding domain, a coiled-coil domain and a WD-40 repeat motif [40][45][46].

## 4. Receptors

To initiate transduction, a signal must first be sensed by a receptor. Most known receptors are present in the plasma membrane, although some are located in the cytosol or other cellular compartments. Three classes of membrane-located receptors have been identified in animal cells and they are as follows: 1. G protein-linked recptors: when activated, they convey information to a protein that binds GTP as the first stage in transduction. The G-protein α-subunit is usually released from the β/γ-subunits into the cytoplasm, where it can activate other enzymes.2. Enzyme-linked receptors are commonly protein kinases. Binding of the ligand causes the receptor to dimerize, leading to intermolecular phosphorylation with activation of the receptor. 3. Ion-channel-linked receptors may be coupled directly to important cell surface channels that open when the receptor is occupied[19, 47, 48].

## 5. Receptor-like kinases in plants

Development of multicellular organisms relies on coordinated cell proliferation and differentiation. In animals, growth factor receptor kinases play key roles in cell differentiation and development, either by stimulating or inhibiting cell growth. Recent studies revealed that higher plants also possess genes coding for putative receptor kinases [49-52]. Recent studies revealed that the receptor serine/threonine kinases comprise the largest and most diverse class of receptor proteins in plants. For instance, a completely sequenced Arabidopsis genome contains over 500 genes encoding RLKs, suggesting that higher plants, like animals, use receptor kinase signaling commonly and broadly in responding to vast arrays of stimuli to modulate gene expression. Although only a handful of RLks thus far are shown to have defined biological functions, their roles in development, self-incompatibility response, and defense against pathogens illustrate important and versatile function of the RLK super family. However, given that only a few RLKs have been shown to regulate developmental processes, it is far from being understood how receptor-kinase signaling control cell proliferation in plants. A common feature of these putative receptor kinases (RLKs),is that each has an N-terminal signal sequence, an extracellular domain that varies in structure, a single membrane-spanning region, and a cytoplasmic protein kinase catalytic domain (see Fig 4). Unlike animals, where a majority of the receptor kinases possess tyrosine kinase activity, all of the plant RLKs thus far are shown to phosphorylate serine-threonine residue, except one that displays dual specificity in vitro [50, 53, 54]. Plants RLKs are classified into 7 sub-families based on the structural feature of the extracelluar domain, which is thought to act as aligand-binding site.

S-domain class: S_RLKs possess an extracellular S-domain homologous to the self-incompatibility-locus glycoproteins (SLG) of Brassica oleracea . The S-domain consists of 12 conserved cysteine residues (ten of which are conserved). In addition, the S-domain possesses the PTDT-box, which has a conserved WQSFDXPTDΦL sequence (x, non conserved amino acid; Φ, aliphatic amino acid). In Brassica, the S-RLK gene is physically linked to the S locus [51]. It has been shown that the S-RLK primarily functions as a receptor for the pollen-derived ligand, SCR (S-locus cysteine rich protein) during the self-incompatibility recognition process between pollen and stigma. The SLG protein is required for a full manifestation of the self-incompatiblity response. However, isolation of several S-RLK genes from self-compatible plant species and their expression in vegetative tissues indicate that S-RLKs may play a developmental role in addition to self-compatibility. In addition, one of the S-RLKs of BrassicaI is implicated in plant defense response [55, 56]. LRR class:The leucine-rich-repeat class is the largest family, comprising more than 170 genes in Arabidopsis. LRRs are tandem repeats of approximately 24 amino acids conserved leucines. LRRs have been found in a variety of proteins with diverse functions, from yeast, flies, humans, and plants, and are implicated in protein-protein interactions. Several LRR-RLKs have been shown to play critical roles in development. Those include ERECTA which regulates organ shape, CLAVATA1 which controls cell differentiation at the shoot meristem, HAESA, which regulates floral abscission process, and BRI1, which is involved in brassinosteroid perception [57][58][59][60]. On the other hand, rice gene Xa21 confers resistance to Xanthomonas oryzae pv oryzae [61]. Therefore, LRR-RLKs also play a role in disease resistance. Interestingly, the tomato Cf disease resistance gene products, which confer a race-specific resistance to Cladosprium fulvum, contain extracellular LRR domains but lack the cytoplasmic protein kinase domain. Because LRR domains typically mediate protein-protein interactions [62-64], the ligands of these receptors are expected to include peptides.

TNFR class: The maize CRINKLY4 (CR4) gene product possess TNFR (tumor-necrosis factor receptor)-like repeats, that has a conserved arrangement of six cysteines, and seven repeats of ~39 amino acids that display a weak similarity to the RCC GTPase [65][66][67]. CR4 is required for a normal cell differentiation of the epidermis [68]. The Arabidopsis genome contains several genes related to CR4 [67, 69].

EGF class: The cell wall associated receptor kinases (WAKs) represent the EGF (edpidermal growth factor) class. The EGF=like repeat motif is characterized by a conserved arrangement of six cysteines. The EGF-like repeats are found in variety of animal extracytoplasmic receptor domains and are known to play a role in protein-protein interactions. In Arabdopsis, four WAKs (WAK1 to WAK4) have been identified, and all of them have extracellular EGF-like repeats [70]. Reverse-genetic experiments suggest that WAKs may be involved in pathogenic responses.

PR class: The Arabidopsis PR5K (PR5-like receptor kinase) is the known example of this class. The extracellular domain of PR5K exhibits sequence similarity to PR5 (pathogenesis related protein 5), whose expression is induced upon pathogen attack [21, 71, 72]. The structural similarity between the PR5K receptor domain and PR5 suggests a role for PR5K in pathogenesis response.

Lectin class: The Arabidopsis LecRK1 gene product possesses an extracellular domain homologous to carbohydrate-binding proteins of the legume family. Although biological function of LecRK1 is yet known, its structure feature suggests that LecRK1 may be involved in a perception of oligosaccharide-mediated signal transduction. The Arabidopsis genome contains >30 genes belonging to Lectin-RLKs several genes coding for Lectin-RLKs [73].

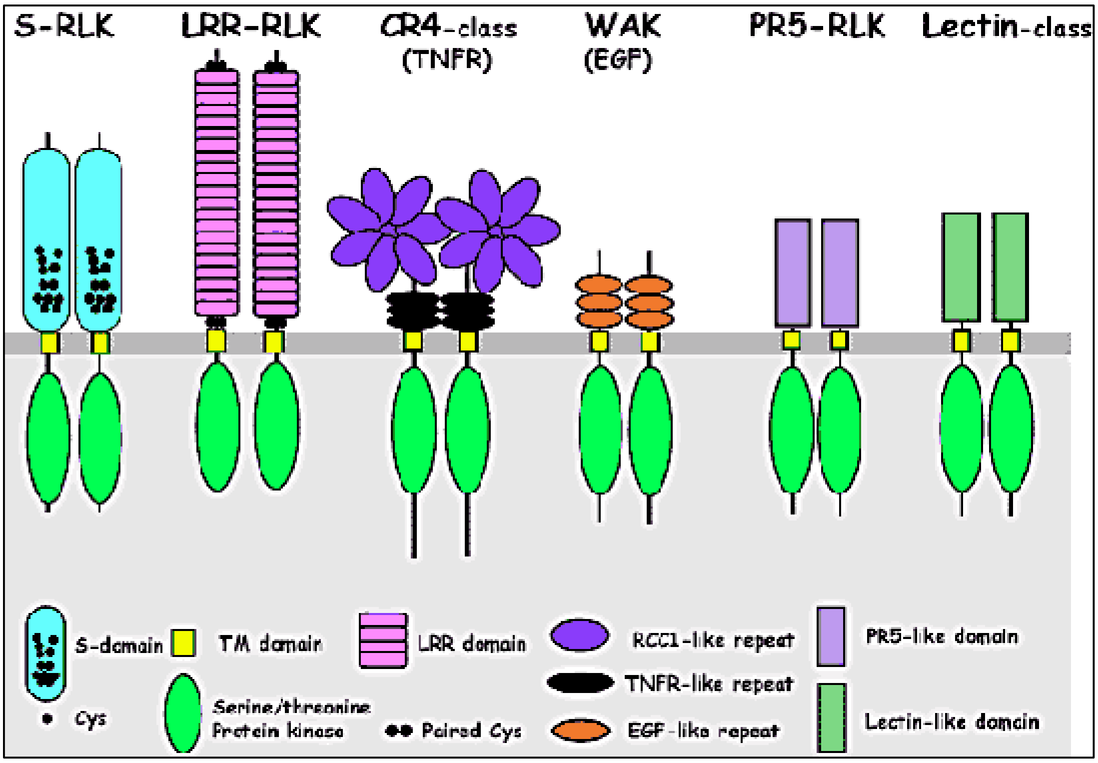


*Fig 4. Structural families of Receptor S/T Protein Kinases in Plants*

Six major families of plant receptor kinases are classified by their putative extracellular domains. Approximate gene numbers for each family in *Arabidopsis* are indicated. Where known, genetically defined functions for members of each family are listed in the text. The S-type and LRR-, CR4-receptors [74][75-77]; WAK type (Wall-Associated Kinase) [78]; PR type (pathogenesis related); lectin type[79]

## 6. Signaling in Plant Development

All higher plants possess several classes of photoreceptors. Phytochromes (phyA-phyE) sense red and far-red light. Three distinct photoreceptor families as mentioned in above setion: for example phototropins (phot1 & phot2), cryptochromes (cry1 & cry2) and the Zeitlupes (ZTL, FKF1 & LKP2) sense UVA/blue light. UVB-receptors are currently unknown. These photoreceptors allow plants to sense the intensity, quality, periodicity (day-length) and direction of light. These photoreceptors control important developmental transitions (e.g. the induction of flowering). Cryptochrome and phytochromes also determine whether a seedling will adopt an etiolated development (after germination in the dark) or a photomorphogenic development when the seedling develops in the light. The etiolated mode of development allows the seedling to rapidly emerge from the soil into the light. Shade avoidance and phototropism are two important adaptive responses, which allow seedlings to optimize photosynthetic light capture. The list of Arabidopsis photoreceptors is presented in Fig. 5.

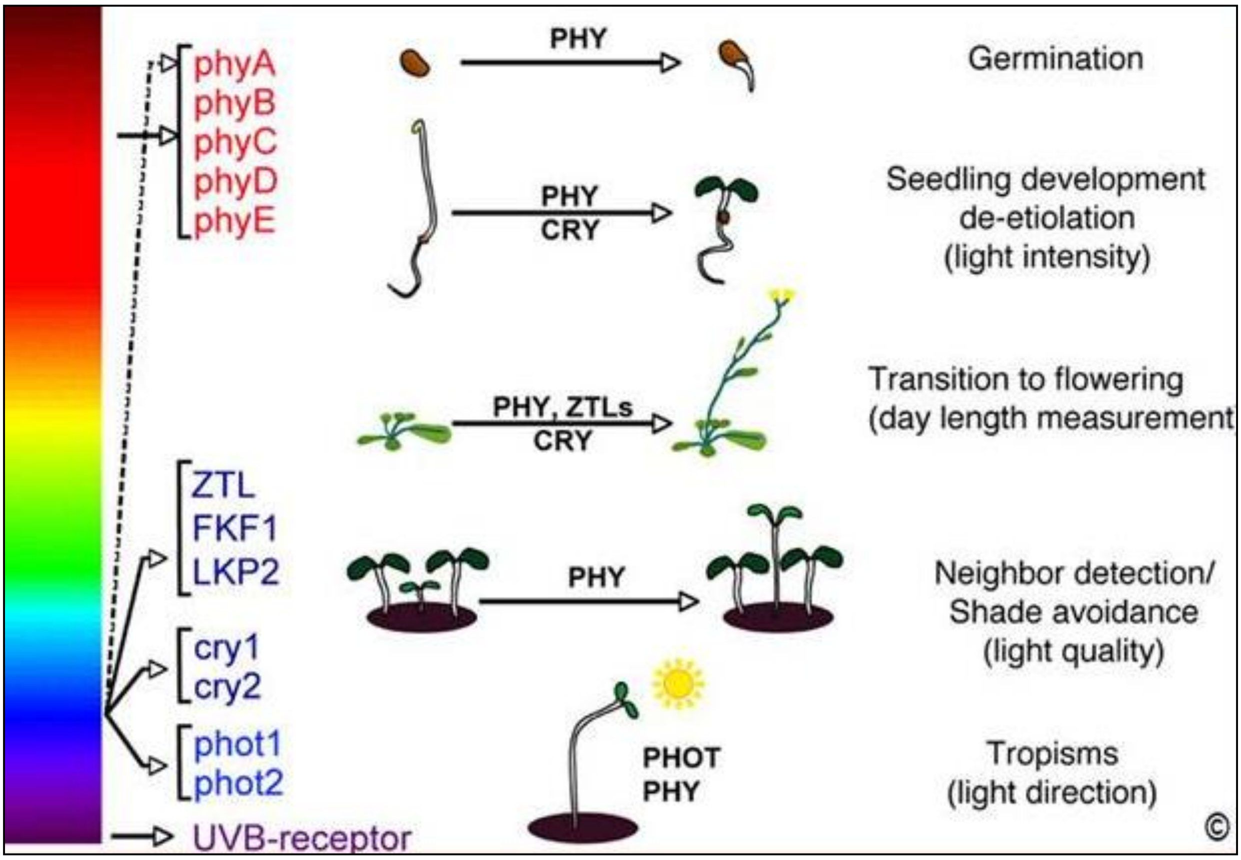


*Fig 5. The effect of light on plant growth and development[1]*

At the level of biological function, there is substantial evidence that key elements of signaling pathways related to stress [80-82], defense [83], sugar [84, 85], and osmotic responses [86, 87] are at least partially conserved in plants, animals, and fungi. These conserved pathways regulate processes that are basic to unicellular as well as multicellular organisms. For example, sugar sensing provides a mechanism for long-distance communication between plant organs [84, 85]. In contrast, the signaling pathways that underlie much of multi-cellular development and pattering are, as far as we can tell, highly novel in plants. The Ras, Wnt, and hedgehog signaling pathways that are central to animal development [88] are not detected in plants. Although auxin signaling is mediated by a highly conserved ubiquitin mediated proteolysis apparatus; the downstream targets of the auxin-regulated SCFTIR1 complex are highly novel and plant specific.The generalization that developmental pathways are less conserved than responses common to unicellular organisms is consistent with the hypothesis that multi-cellular development occurred independently in plants and animal lineages.

[1]http://www.unil.ch/cig/en/home/menuinst/research/research-groups/prof-fankhauser.html

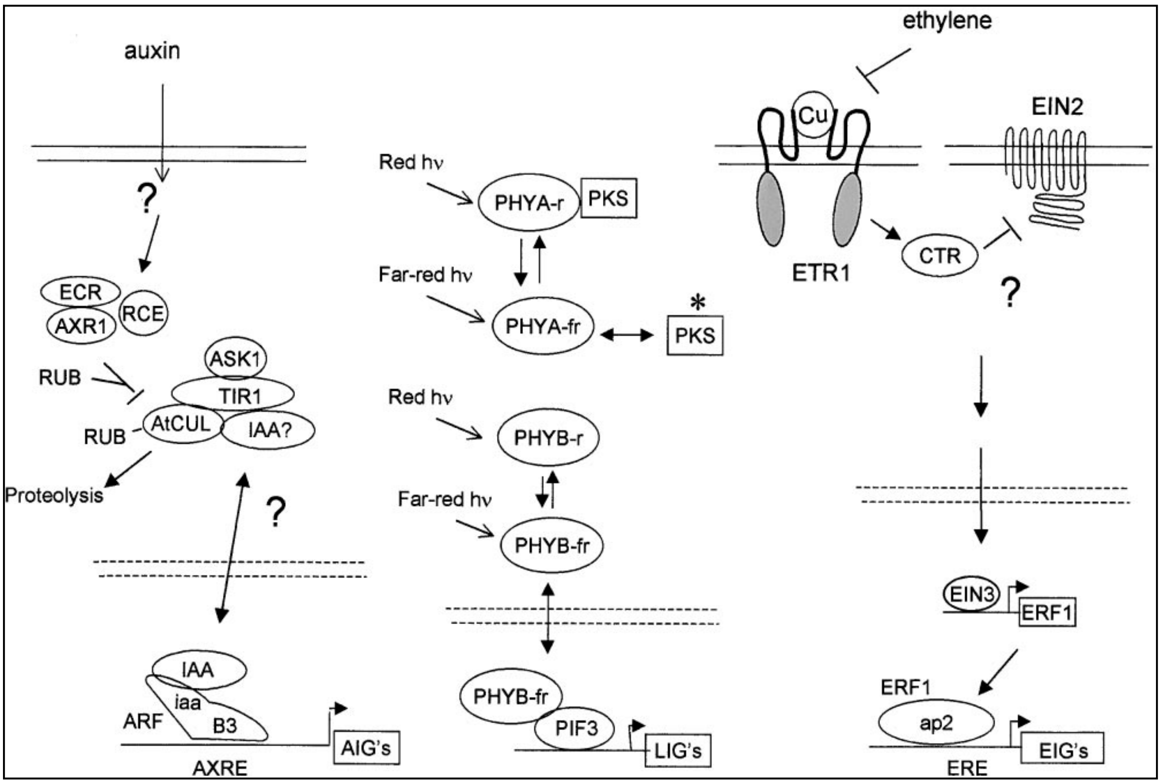


*Fig 6. A simplified diagram for key signal transduction pathways for auxin, red, and far red light and ethylene in Plants. Two defined activities of PHY-fr are shown. PHYA-fr phosphorylates PKS1 localized in the cytosol Nuclear localized PHYB-fr interacts specifically with the PIF3 transcription factor, effecting regulation of one class of light-induced genes (LIGs). The ERF transcription factors contain AP2 DNA binding domains specific for the ethylene response elements in promoters of ethylene induced genes (EIGs). AIG, auxin induced gene. Cell membranes are represented by paired horizontal lines, dashed lines represent the nuclear envelope (see[89]).*

The hormone pathways-auxin, cytokinin, abscisic acid, gibberellin, and ethylene, brassinosteroid-appear to be very important in many contexts in plant development (see Fig 6).Recently, the concept of cross-talk between hormones has attracted much attention with the idea that hormone signaling pathways make up a complex interacting web of informational transfer that allows a variety of stimuli to cause a plethora of overlapping responses [23]. Much of the evidence for signaling cross-talk in hormone biology comes from genetic studies using the model plant Arabidopsis thaliana. A number of molecular mechanisms have been identified that explain the interactions between hormones. Genetic perturbations of one hormone response can cause changes in the synthesis or degradation of another hormone [90]. Alternatively, hormone signaling pathways can share signaling components so that both pathways are disrupted by a single mutation [91]. In this review one of our aims is to update the knowledge related to the growing relationship between hormone signaling and developmental studies with the intention of demonstrating that developmental context is required for a full understanding of how a hormone functions.

Auxin (indole acetic acid) regulates many aspects of plant growth and development and plays a pivotal role in many processes throughout the plant life cycle. These include embryogenesis, lateral root development, vascular differentiation, apical dominance, tropic responses and flower development [92]. In spite of the tremendous amount of information that has accumulated, the auxin signaling pathways have not been fully elucidated. The known primary auxin responsive genes include three gene families called the AUX/IAA, GH3 (growth hormone) and SAUR (small auxin-up RNA) families [93]. The AUX/IAA proteins are short –lived nuclear proteins that function as transcription regulators.These proteins do not interact directly with DNA but exert their regulatory activity through another group of proteins called auxin responsive factors (ARFs). There are at least 29 AUX/IAA genes in the Arabidopsis genome. Most of the AUX/IAA proteins share four conserved domains, designated domains I to IV. Domains III and IV are located in the C-terminal half of the protein and are involved in homo- and heterodimerization with other AUX/IAA proteins and heterodimerziation with ARFs that also share domains III and IV (also called the CTD or C-terminal domain). Additionally, ARFs contain an N-terminal DNA binding domain (DBD) . There are 23 ARF genes in the Arabidopsis genome and all but two (ARF3/ETTIN) and ARF17) contain the CTD region [94][95].

ARFs bind to conserved DNA sequences (TGTCTC) called auxin-responsive elements (AXRE) in the promoter regions of primary/early auxin response genes [95]. ARFs can act as either transcriptional activators or repressors depending on the nature of their middle region (MR) domain. The ARFs with a Q-rich MR function as activators, whereas other RFs with a P/S/T-rich MR function as transcriptional repressors [94]. The half-life of these proteins in wild-type Arabidopsis seedlings ranges from ~10 min to ~80 min, depending on the protein [96][97][98]. This short half-life can be extended several fold by treatment with proteosome inhibitors such as MG115 and MG132, indicating that the degradation of the AUX/IAA proteins is associated with the proteosome pathway [98].

This auxin signaling is mediated by a highly conserved ubiquitin ligase complex (Ubiquitin-proteosome pathway) [92][99-104]. The pathway is defined by the AXR (AUXIN RESISTANT) and TIR (AUXIN TRANSPORT INHIBITOR RESISTANT) mutants of A. thaliana. AXR1 and a partner protein, ECR1, comprise a RUB (related to ubiquitin)-activating enzyme analogus to E1 of the ubiquitin pathway [99, 101-104]. These proteins together with a RUB-conjugating enzyme, RCE1, RUB-modify AtCUL, a cullin homolog [92]. AtCUL is a component of an SCF (SKP-culin-F-box) ubiquitin ligase complex that includes TIR1, the F-box protein, and ASK1, a homolog of yeast SKP1 [96, 105]. Mutation in TIR1 and ASK1 inhibit the auxin response, suggesting that the SCFTIR1 complex regulates turnover of a repressor. Possible downstream targets of the SCFTIR1 comple include IAA domain proteins such as those defined by the dominant auxin insensitive mutants, AXR2 and AXR3 [106, 107]. The IAA homology domain is conserved in a large family of auxin induced proteins in plants. Dominant muatations in the IAA domain that confer insensitivity to auxin also strongly inhibit turnover of IAA proteins [108]. Protein-protein interactions mediated by the IAA domains are proposed to modify activity of the ARF (auxin responsive factor) transcription factors bound to auxin response elements (AXRE) of auxin induced genes [94, 106]. Key components of ethylene signal transduction pathway include ETR1 (ETHYLENE TRIPLE RESPONSE-1), the ethylene receptor; CTR1 (CONSTITUTIVE ETHYLENE RESPONSE-1), a raf-like protein kinase; EIN2 (ETHYLENE INSENSITIVE-2), a membrane protein related to mammalian NRAMP proteins; and EIN3 (ETHYLENE INSENSITIVE-3), a novel transcription factor. In the absence of ethylene, ETR1 and related receptors actively inhibit the ethylene response. The inhibitory action of ETR1 requires the CTR1 kinase. Hence, ethylene binding to ETR1 is proposed to cause inactivation of CTR. Inactivation of CTR1 potentiates signaling mediated by the C-terminal cytoplasmic domain of EIN2 [91]. ENI2 signaling leads to activation of the ENI3 transcription factor in the nucleus. ENI3 is a direct activator of the ETHYLENE RESPONSE FACTOR [109] genes. ERF transcription factors in turn bind to ethylene response elements of downstream ethylene induced genes.

Abscisic acid (ABA) was discovered independently by several groups in early 1960s. Originally believed to be involved in the abscission of fruit and dormancy of woody plants, the role of ABA in these processes is still not clear. ABA is, however, necessary for seed development, adaptation to several abiotic stresses, and sugar sensing. The regulation of these processes is in large partly mediated by changes in de novo synthesis of ABA.

Our understanding of the function and synthesis of ABA has been greatly enhanced by the identification and characterization of ABA-deficient mutants [110]. The ABA–deficient mutants have been identified by the following phenotypes: precocious germination, susceptibility to wilting, an increase in stomatal conductance, and an ability to germinate and grow on media containing a high concentration of sucrose or salt. Several genes involved in ABA signaling pathways have been isolated from Arabidopsis. These include genes for protein phospahtases (ABI1 and ABI2) and for putative transcription factors (ABI3-5). One of the well studied ABA signaling pathways is the closure of the stomatal pore in response to ABA [111]. ABA application is known to cause elevation in guard cell cytosolic ($Ca^{2+}$) ion levels, and oscillation in cytosolic ($Ca^{2+}$) are necessary for stomatal closure [111].

The pH and redox status of the cell are crucial factors in mediating or regulating ABA signal transduction. Cytosolic increases in both H2O2 and NO concentrations occur in guard cells before (exogenous) ABA-induced stomatal closure [112][113, 114]. Interestingly, both of these secondary messengers are associated with pathogen interactions and with $Ca^{2+}$cyt increases that are indicative of the convergence of different pathways at the level of $Ca^{2+}$ oscillation [115].

The growing list of ABA-response regulators comprises G proteins; protein phosphatases, such as PP2Cs; and protein kinases of the calcium-dependent protein kinase (CDPK) and SUCROSE NON-FERMENTING PROTEIN-1 (SNF-1) - like groups [116].

Analysis of GPA1 (Gα subunit of a heterotrimeric G protein) implies a role for heterotrimeric G proteins in modulating ABA responses [71, 72, 117], and there is strong evidence that small G proteins also regulate ABA responses [118][119]. The Rho-like small G protein ROP10 negatively regulates ABA-mediated stomatal closure, germination and growth inhibition [119]. The recruitment of ROP10 to the plasmamembrane requires a functional farnesylation site and is a prerequisite for altering ABA responses. Hence, the role of ROP10 in ABA responses is reminiscent of the role of the small G protein RAS in the mitogenic response of mammals. Interestingly, ROP proteins are also associated with increased H2O2 production because of their activation of NADPH oxidases and, together with H2O2-induced ROP deactivators, are part of redox rheostat [120]. ROP2 and ROP6/AtRac1 contain a putative geranylgeranylation motif, and the expression of dominant –negative and constitutively active forms of both of these small G proteins characterized them as peliotropic negative modulators of ABA responses [118][121, 122]. The roles of ROP2 and ROP6/AtRac1 were linked to reorganization of the actin skeleton and to vesicle transport, which are required for both stomatal closure and tip growth [118][121, 122]. In this context, a syntaxin deficiency in osmotic stress-sensitive mutant (asm1) gave rise to impaired vesicle transport or fusion and resulted in ABA-insensitive stomatal regulation [86]. Transcriptome analyses have shown that ABA dramatically alters genomic expression [123][3]. More than 1300 ABA-regulated genes were identified by random massive sequencing of Arabidopsis transcripts, of which half showed decreased expression in response to ABA [123]. ABA regulation of the majority of the1300 genes (more than 90%) was impaired in abi1-1, emphasizing the central role of this locus in ABA signal transduction.

The control of ABA on gene expression and on the proteome includes posttranscriptional processes, such as mRNA maturation and control of the stability of transcripts and proteins. ABA strongly down regulates the expression of ribosomal proteins and concomitantly up regulates the genes that are involved in proteolysis [123]. In addition to ABA-mediated control of TFs, the regulation of RNA polymerase II (RNAP II) has been identified as a novel control point in plant stress signaling [86].

Plants utilize a variety of metabolites as signaling molecules, including many that have analogs in other eukaryotes. Hormones derived from aromatic amino acid, steroid, apo-carotenoid, and fatty acid derivatives mirror major classes of animal hormones.

The brassinosteroid (BR) and abscisic acid (ABA) hormones are analogs of steroid and retinoid hormones of animals, respectively [124]. Key steps in plant and animal steroid biosynthetic pathways are highly conserved. The human steroid 5α-reductase type I or type II genes, for example, rescue the Arabidopsis det2 mutant, which is deficient in the synthesis of the steroid hormone brassinolide [124]. The apo-carotenoid, retinoic acid and abscisic acid, are derived from oxidative cleavage of plant carotenoids. The biochemical mechanism of apo-carotenoid synthesis was illuminated by analysis of viviparous14, an ABA-deficient mutant of maize [110]. VP14 defines a new class of dioxygenases that catalyze specific oxidative cleavage of carotenoids. Related genes are found in genomes of animals and bacteria that synthesize apo-carotenoids [110], suggesting that this mechanism is broadly conserved in nature.

Brassinosteroids (BRs) are steroidal plant hormones that are essential for growth and development. They are essential factors for cell and stem elongation, unrolling of grass leaves, bending of grass leaves at the sheath/blade joints, xylogenesis, and ethylene production. BR biosynthesis and sensitivity mutants show dwarfism and, when grown in the dark, share some characteristic with light grown plants [125]. The identification of components of the BR signal transduction pathway revealed different modes of transcriptional control in animal and plants. Steroid signaling in plants appear to be perceived at the plasma membrane through a leucine-rich-repeat (LRR)-receptor ser/thr kinases BRI1 and BAK1 [49]. Localization of these receptor kinases on the plasma membrane suggest that BR signaling is initiated on the cell surface [49]. Moreover, the extracellular domain of BRI1 confers BR responsiveness to heterologous cells [77]. The possibility that membrane–bound steroid receptors exist in animals remains; however, LRR receptor S/T kinases related to BRI1 are not found in animal genomes. BR signaling is reminiscent of growth factor and TGF-B signal transduction in animals. It is possible that the use of steroid signals is ancient and that the signal transduction mechanisms have diverged radically in plants and animal lineages. The phosphorylation cascade could be a basis of extensive cross-talk and thereby explain the complexity of BR response [126-130].

Jasmonic acid (JA) and related octadecanoid compounds are cyclic products of lipid oxidation and are structurally related to prostaglandins, autacoidal hormones that have a variety of physiological activities in mammals. Both JA and prostaglandins are derived from fatty acids. JA signal pathway involves several signal transduction events: the perception of primary wound or stress stimulus and transduction of the signal locally and systemically; the perception of this signal and induction of JA biosynthesis; the perception of JA and induction of responses; and finally, integration of JA signaling with outputs from the salicylic acid, ethylene, and other signaling pathways [131][132].

Salicylic acid (SA) is a central signaling molecule responsible for the coordinated expression of pathogenesis related (PR) genes and the onset of systemic acquired resistance [133]. SA-mediated responses appear to involve multiple steps including early oxidative signaling, which helps to establish the reducing conditions that are necessary for a key regulator, the NONEXPRESSOR OF PR GENES 1 (NPR1) monomer, to enter the nucleus. Multiple and redundant TGA transcription factors cooperate with nuclear NPR1 to activate the expression of late PR genes. Mutations in the Cys residues of NPR1 and some of TGA confirm that protein translocation and transcription activation are modulated by cellular redox states. New evidence also supports the concept that a single NPR1 protein has multiple functions in different subcellular locales, which presumably rely on interactions with distinct or overlapping partners. New transcription factors that are involved in NPR1-independent SA regulation of gene expression have also emerged.

## 7. Conclusions

Signal transduction is an actively expanding topic of research in plant biology. Signals, which include a wide array of external and internal stimuli, are amplified and communicated by complex signal transduction networks, most of which initiate with the activation of receptor proteins. Bacterial receptor and transduction systems provide models for plant receptors, including proteins that sense ethylene and phytochrome. Among the various plant signal transduction pathways that have been identified many of the components are common to many signal transduction networks in animals, such as GTPases and phospholipids derivatives. Investigations into the roles of GTPases in plant signal transduction has been progressed considerably and several small GTP binding proteins have been implicated in these processes. Cyclic nucleotides also appear to act as a second messengers in plant cells and most likely interact with another second messenger, cytosolic calcium. Calcium channels and other calcium transporters form the basis of a complex $Ca^{2+}$ signaling network in plants. Protein kinases are the most common transduction components interpreting signal in plant cells. Various classes of protein kinase act in concert with protein phosphatases to mediate plant cell signaling and control metabolism. Plant hormones are important elements in controlling plant growth and development, and progress is being made in understanding how cell transduce these signals. . Photoreceptor induced signaling mechanism influence numerous aspects of plant development; however, our understanding related to the the photorecptor mediated plant development at molecular level is limited. Inspite of the considerable progress in elucidating the molecular events underlying in photomorphogenesis, there are still a large number of unresolved issues. Advances in signal transduction research are rapidly expanding our understanding of how plant cells communicate and cooperate.

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

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